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STUDIES OF GASTROPODA.

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MARINE gastropods appear to have reached their acme of development in the present geologic period. What the Jurassic and early Cretaceous time was to the cephalopods, the Tertiary and present periods are to the gastropods. This is indicated not only by the great number of species, but also by the fact that so many series have branched out into bizarre types, in which excessive development of spines and tubercles suggests that the limit of variation is approached.[2]

Phylogerontic types are furthermore to be found in the majority of series, while some groups, such as Strombus, Cypræa, etc., are represented only by phylogerontic forms in the modern seas.

[1] The author has for the past five years been engaged in the study of the phylogeny of gastropods, particularly the Fusidæ and some related types. A monograph on Fusus and some of its allies is ready for the press, while another, dealing especially with Fulgur and its allies, is in preparation. The present paper is intended as a contribution to the principles of study of the molluscan shell as applied to Gastropoda, principles first worked out for the Cephalopoda by the late Prof. Alpheus Hyatt and some of his contemporaries, and for the Pelecypoda by Prof. R. T. Jackson.

[2] See Beecher, Origin and Development of Spines, *Amer. Journ. of Sci.*, Ser. 4, vol. vi (1898), pp. 329-359; also *Studies in Evolution*, pp. 93 *et seq.*, Scribner, 1901.

The Protoconch of Gastropods. — The apical whorl of a gastropod shell has come to be generally known as the protoconch, though this term had been preoccupied for the corresponding apex of cephalopod shells. The protoconch of gastropods is essentially different from that of cephalopods in that it is (at least in the majority of types) twisted into one or more coils of a spiral nature, whereas that of cephalopods, so far as known, is a mere swollen bulb. The earliest portion of the gastropod protoconch agrees essentially in form with that of the cephalopods (Spirula, Ammonoidea) and pteropods, but spiral coiling appears very early in the majority of forms. Thus the protoconch of the Gastropoda may on the whole be considered as more specialized than that of the Cephalopoda. It might perhaps be thought desirable to dignify this specialized type of protoconch by a distinct name, as has been done by Jackson in the case of the pelecypod protoconch ("prodissoconch"). If so, the name "protorteconch," suggested to me by the late Professor Hyatt, would be most applicable. The shell or conch of gastropods may be specifically described by the term "torteconch," a name also used for the spirally coiled shell of cephalopods (Turrilites, Trochoceras).

The characteristics of the protoconch of most living gastropods are very variable, as might perhaps be expected in a class whose living members are on the whole highly specialized. Even in Tertiary times this specialization of the protoconch is noticeable. It is not always possible to determine the precise line of demarcation between protoconch and conch, since in a large proportion of types the two grade into each other imperceptibly. In certain types (Buccinum, etc.) a line and a slight change in the growth of the shell indicate the place where we may most reasonably make the separation between protoconch and conch. In a number of cases (Fusus, Hemifusus, certain Murexes, etc.) the end of the protoconch is strongly marked by the existence of a pronounced varix and an abrupt change of ornamentation (Fig. 5). In the majority of cases, however, no

FIG. 1. — *Rhopalithes rugoides* nov. gen. et sp., showing a fusoid (bulbous) protoconch with riblets on last portion and an abrupt beginning of the conch. Eocene. Paris Basin. × 10.

such definite line of demarcation exists. In general, the protoconch coils in the same direction as the conch, though conspicuous exceptions to this rule are found in Pyramidellidæ and other groups.

The early whorls of the protoconch of gastropods (except such ovoviviparous types as Cymbium) are smooth rounded coils of the type found in adult Natica, and best exemplified by *Lunatia heros* of our northern coast. In the majority of cases the initial whorl is minute, while the succeeding ones enlarge gradually and regularly. In some types the initial whorl is large and swollen (Fusus, Hemifusus, Fulgur, etc., Figs. 1, 7), when it is generally more or less elevated and oblique, a feature carried to excess in certain volutes. This type of protoconch has been termed "bulbous" by Dall.[1]

FIG. 2. — *Clavilithes rugosus* (Lam.). Eocene. Paris Basin. The apical whorls × 10, showing papillose protoconch and early conch whorls.

Again the initial whorl may be compressed so as to produce a conical form, the sloping sides of which are flat. This type, observable in so-called Clavilithes from the British and American Eocene and in some other genera, may be denominated a "trochoid" type of protoconch.[2] The flattening may be confined to the apical whorl or may be continued over one or more of the succeeding whorls. The normal naticoid type of whorl may continue, with regular increase, thus giving rise to the large "Melo" type of protoconch (Dall) so prominent in Melo and some other genera. When the whorls become depressed so as practically to lie in one plane, a "planorboid" protoconch is produced (Dall). Again the naticoid initial whorl may be succeeded by a number

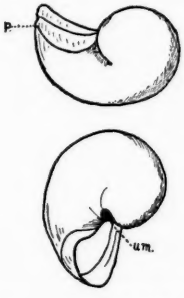


FIG. 3. — Protoconch of *Sycotypus canaliculatus*. *p*, end of protoconch; *um*, umbilicus. × 14.

[1] *Trans. Wagner Free Inst.*, vol. iii (1890), p. 67.

[2] The "trochiform" type of protoconch of Dall is more comprehensive, including the naticoid type.

of whorls which increase slightly or not at all in size, thus giving a long and slender type of protoconch which Dall has called "pupiform." This type of protoconch is characteristic of Clavilithes of the Paris Eocene (Fig. 2), of many Eocene and recent species of Turbinella, and of other forms.

The trochoid type of protoconch is apparently a case of specialization, and is confined to a comparatively small number of gastropods.

The naticoid initial whorl of the protoconch, so far as has been observed is umbilicated. This is well shown in Fulgur,

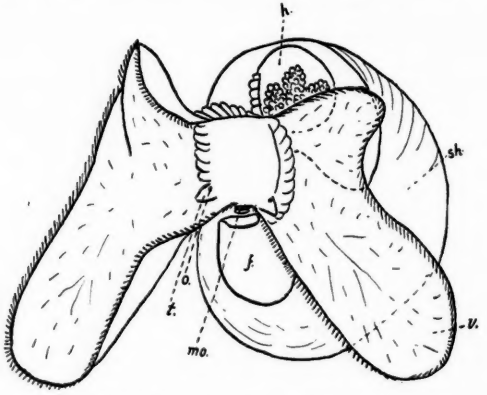


FIG. 4.—*Sycotypus canaliculatus* in the phylembryonic stage. *f*, foot; *h*, heart; *mo*, mouth; *o*, eye; *sh*, shell (protoconch); *t*, tentacle. × 30.

Sycotypus, Fasciolaria, Buccinum, and other types in which the initial whorls are large enough to be readily examined. The umbilicus is best shown in young individuals which have just completed the early protoconch stage (Fig. 3). It is well marked in Fulgur at the end of the protoconch (phylembryonic) stage, before the velum is fully developed (Fig. 4). This latter persists until just before the animal leaves the egg capsule, by which time the young conch has begun to develop and the umbilicus is closed. I believe that we are warranted in assuming that the umbilicus exists at some stage in the protoconch of the majority of gastropods, though it is conceivable that in extremely accelerated types, even this — apparently the most

primitive condition of a coiled protoconch — is lost. From the characters of the initial whorls of the protoconch we may argue that the radicle of the coiled gastropods must have been a naticoid type with a well-marked umbilicus. Such a type is found in *Straparollina remota* Billings, one of the earliest coiled gastropods of the Etcheminian or Lower Cambrian of the Atlantic border province of North America. That it is probably not the most primitive type of gastropod is suggested by the consideration that the earliest stage (ana-phylembryonic) of the protoconch is not coiled, but rather cap-shaped like modern Patella. Such primitive types are found in Lower Cambrian species which have variously been referred to Platyceras, Scenella, or Stenotheca, owing to the want of sufficient characteristics to define their exact relations.

FIG. 5. — *Hemifusus colosseus* Lam. Recent. Apical whorls × 4, showing oblique bulbous protoconch with riblets in the last portion, and the abruptly beginning, accelerated conch with the shoulder developed at the beginning.

Our modern patelliform shells are probably not primitive types, as shown by the protoconchs of Acmæa and Crepidula, which are coiled.

Ornamentation of the Protoconch. — In a number of species of gastropods the later whorls of the protoconch are ornamented by riblets (Figs. 1, 5), and more rarely by true revolving lines or spirals. In others a carina appears on the whorls of the protoconch.[1] These structures normally belong to the conch, where their strength and variation constitute the chief features by which the whorls are characterized. Their occurrence on the protoconch is due to a backward pushing of the normal conch characters, until they appear on the final whorls of the protoconch. This is in conformity with the law of tachygenesis, or acceleration in development, which is the key to the understanding of the taxonomic values of shell characters in

[1] For an account of the characteristics of the protoconchs of a number of gastropods, see Baker, F. C., On the Modification of the Apex in Gastropod Mollusks, *Ann. N. Y. Acad. Sci.*, vol. ix (1897), pp. 685–704, Pls. XVIII–XX; also *Proc. Phil. Acad. Sci.* (1890), pp. 66–72; (1894), pp. 223–224; *Roch. Acad. Sci.* (1891), pp. 130–132.

gastropods. Such accelerated type of protoconch is particularly characteristic of the Fusidæ, though not confined to them. In some members of this group, *i.e.*, *Fusus caloosaensis* and its congeners, the ornamentation of the protoconch begins very early, showing extreme acceleration. This is also true of *Fusus apicalis* Johnson. Neither of these species is a true Fusus.

The classificatory value of the protoconch of gastropods has not generally been recognized, Dall, so far as I know, being the only author who has made extensive use of it. It is, however, apparent that if our classification is to express genetic relationship, this, the earliest formed portion of the shell, demands a careful consideration. It is generally conceded that organisms of a common ancestry are more nearly alike in their earliest stages of development, differentiation becoming more and more marked in later stages. This is to be expected if the law of recapitulation of ancestral characters is accepted, for then the earlier stages must more nearly represent the features of the immediate ancestor in any particular restricted group. Furthermore, the smaller the taxonomic group, the more nearly identical must be the earlier stages, since in a small group the members have not become widely separated from their common ancestor. Thus, while the initial whorl of the protoconch does not differ widely, except in size, in the majority of gastropods, indicating the characters of the more distal radicle of the class, — *i.e.*, the naticoid ancestor, — the whole character of the protoconch must be considered in the determination of the more immediate relationships. Therefore, I believe it is not too much to say that the protoconchs of all the species within a given genus should agree as to their essential characteristics, and that no species can be considered congeneric in which the protoconchs show a radical difference. Thus, as will be shown in a forthcoming memoir on Fusus and some of its allies, the American Eocene species of Fusus do not show the typical Fusus protoconch, but some have a protoconch like that of many species of Pleurotoma and like *Levifusus trabeatus* (*i.e.*, *Fusus meyeri*, etc.). Others again have the protoconch of Fulgur (*Fusus quercollis*, etc.), of which group they are the Eocene ancestors. The species referred to have adult

conch features closely similar to those of Fusus, and the consideration of these alone has caused them to be placed in that genus. (Compare Fig. 6.) These examples, however, are due to parallelism rather than close genetic relationships. Great similarity exists between the protoconchs of Fusus and Hemifusus, thus showing a close genetic relationship between these two genera, while on the other hand Fasciolaria appears to be more widely removed.

Septa in the Apex of Gastropods. — Gastropoda in which the spire of the shell is long, generally develop septa near the apex. These septa partition off the protoconch and earliest whorls of the conch, and they may generally be seen in specimens with broken apices. Turritella, Cerithium and its allies, Fusus, and in fact turreted shells in general show this septum. It is generally a curved, more or less funnel-shaped element, though often only meniscus-shaped. The septum is invariably convex backward, as might of course be expected. The apical portion is generally uniformly curved and lies freely in the cavity of the protoconch or early conch. Septa are sometimes very numerous as observable in longitudinal sections (Triton, etc.), but generally the number is comparatively small. The septa are entirely imperforate and mark the withdrawal of the apical portion of the coiled visceral hump from the apex of the shell and the cutting off of the useless space by a partition wall. In a number of types the portion of the shell thus divided off becomes invariably broken away. An interesting type of structure which belongs here is found in the recent *Scaphella magellanica* Sby. and some related forms. In this, according to Dall,[1] "the larva is clothed with a cuticular or horny protoconch, probably similar in form to that which when shelly results in the 'bulbous nucleus.' Later on, but while still in

FIG. 6. — *Fusus asper* Sow. A typical primitive Fusus. Eocene. England. × 1⅓.

[1] Dall, W. H. Blake Gastropoda, *Bull. Mus. Comp. Zoöl.*, vol. xviii (1889), p. 452; *Proc. U.S. Nat. Mus.*, vol. xii (1890), p. 311, Pl. IX, Figs. 5, 6; *Trans. Wagner Free Inst. of Sciences*, vol. iii (1890), p. 67, Pl. VI, Fig. 5.

the ovicapsule, the deposition of limy matter begins as a slender cone or elevated point along the line of the axis of the protoconch, and as the larva grows the posterior part of the mantle secretes a shelly dome. Being thus cut off from the horny protoconch, the latter falls into shreds and is lost. The nucleus of the larva, still in the ovicapsule, then presents a slightly irregular dome, with a slender point rising from the apical part." To this apical point Dall has applied the term "calcarella." In this case the protoconch proper was horny and deciduous, while the first formed septum was calcareous and hence came to take the place of the protoconch when this was lost. Probably the types of nuclear whorls named by Dall "Caricella type" and "Scaphella type" from characteristic genera are secondary septal deposits of this type, as already suggested by that author.

Characteristics of the Conch. — The simplest type of whorl of the gastropod conch (torteconch) is round and smooth, showing only the lines of growth. This type, which is virtually only a continuation of the primitive protoconch whorls, is seen in Natica and similar types, and in these the umbilication is generally retained. Omitting Pleurotomaria[1] and its allies, this type of gastropod is most characteristic of the Paleozoic strata, the chief modification being the elongation of the spire, thus producing a loxonemoid type.

FIG. 7. — *Fusus porrectus* Sow. Eocene. England. Apical whorls × 10, showing bulbous protoconch and characters of early conch whorls.

One of the earliest modifications of the smooth shell is the appearance of spirally revolving, more or less elevated lines and the formation of transverse elevated folds or ribs[2] (Fig. 7). Our observations are still insufficient to settle the question as to the order of appearance of these two types of ornamentation. Where both are present the ribs in most cases are the first to appear to the unaided eye, the spirals

[1] The development of Pleurotomariidæ and Bellerophontidæ, and of Euomphalus and other related genera, has been well described by Koken (*Neues Jahrb. für Mineralogie*, Beilage, Bd. vi, pp. 305–483).

[2] These ribs must be distinguished from varices, such as occur in Scalaria, Harpa, and Murex.

not appearing visible until some time after. On the other hand, fine radiating lines — the precursors of the visible spirals — are seen in the embryonic hyaline shell of Fulgur, etc., before it has become opaque by the deposition of secondary calcareous material (Fig. 8). It is most probable, however, that these fine thread-like markings are merely due to a change in the texture of the hyaline shell, corresponding in that respect to the primitive lines of growth, and are not equivalent to the elevated spirals, whose existence is due to a regular, though slight, plication of the mantle edge which builds the shell. If we adopt this view as the most probable one, the ribs, so far as my observations go, must be considered the first modification of the shell in the ribbed and spiraled forms. It is, however, by no means true that spirals do not appear until after the ribs have been formed. In a great many Paleozoic genera ribs never occur, while spirals are well developed. This is well exemplified in the Ordovician genera Cyclonema and Trochonema, the most primitive types of which (*i.e.*, *T.* (*Gyronema*) *liratum* U. and S., etc.) are umbilicated shells of a round-whorled or naticoid outline, with spirals more or less strongly developed. Among the earliest ribbed shells of naticoid form is *Holopea pyrene* Billings from the Middle and Upper Trenton group of Canada and central United States. The ribs are scarcely anything more than coarse undulations, very like the dying stages of the ribbed condition in more highly specialized genera of later geological periods. They have, however, the chief qualities of the ribs in their most accentuated development, and must be regarded as such. As nearly as can be determined from the illustrations given by Ulrich,[1] the earliest stages are free from undulations, thus indicating that, as we

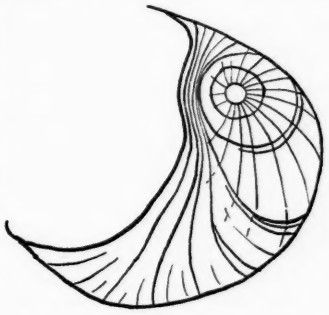


FIG. 8. — Early hyaline shell of Fulgur (Sycotypus), showing primitive lines of growth and fine radiating lines. × 48.

[1] *Palæontology of Minnesota*, vol. ii, Pl. LXXIX, Figs. 13–18.

should naturally expect, the ribbed were derived from the smooth species which precede them immediately in time. The immature specimens of *H. pyrene* illustrated by Ulrich show well the faint beginning of undulations which become pronounced only in the adult.

A somewhat more specialized ribbed shell from another phylum is found in *Natica nexicosta* Phillips of the Devonian. This in form is truly naticoid, with the ribs sharp, narrow, and uniform, separated by uniform intervals which are much wider than the ribs. The earliest stages, as far as can be judged from the illustration,[1] are ribless. The whole aspect of the last whorl of this shell is strikingly like the final whorls of the protoconch of highly specialized Tertiary and recent gastropods. *Natica subcostata* Schl. of the Devonian (Stringocephalen Kalk) of Paffrath, Germany, is another example, in which the costæ or ribs have become compound, secondary shorter ones being intercalated between the longer ones. *Natica costata* from the Lower Trias of St. Cassian carries the simple type of costæ into the Mezozoic era, while *N. armata* from the Upper Trias of that region shows the further complication of revolving spirals which are cancellated by the sharp ribs. In the later forms generally the umbilicus is closed. A similar succession of smooth, simple-ribbed, and cancellated-ribbed shells appears in Jurassic Nerita and Neritopsis, as illustrated by Hudleston in his monograph of the "Inferior Oölite Gastropoda."[2] Among the turreted types simple ribs appear in some of the Devonian Loxonemas, some species of this genus showing the further specialization of cancellating spiral lines. Similar successions may be found in a great many other series, and it is perhaps not too much to say that in the majority of the larger phyletic series, except those highly specialized, the radicle is a smooth, round-whorled form, succeeded by types in which the adults are ribbed, and later cancellated, after which progressive modification may be carried further. The index to the history of the phylum is in general to be found in the life history of the individual member under consideration as revealed

[1] Whidborne. Devonian Fauna of the South of England, *Palæontogr. Soc. Mon.*, Pl. XIX, Fig. 1.

[2] *Palæontogr. Soc. Mon.*, Pl. XXVIII.

by the succession of characters in the shell whorls, from the earliest (nepionic) conch stage to the adult (ephebic) stage.

The revolving elevated lines, or "spirals," may in general be considered as primary and post-primary. The primary ones are the first to appear, and they increase in number by the exogenous appearance of new ones on the upper and lower portions of the whorl, outside of those which appeared first. Secondary spirals appear *between* the primary ones as these diverge, owing to the uniform increase in size of the whorls. Tertiary spirals and spirals of a higher cycle appear in specialized forms, but all such forms begin with only primary spirals, and generally only a few — sometimes even only one of these. The higher cycles come in later progressively, being most numerous in the adult stage. This teaches us that in the primitive type of a series we may expect to find primary spirals only, even in the adult, and experience shows that these are characteristic of the earlier members of any series, and that they generally accompany simple ribs and simple rounded whorls. (See Figs. 6 and 7.)

The first modification in the form of the whorls in gastropod shells is generally a change from the primitive rounded outline to an angular one, which causes the division of the whorl by a median or submedian keel, or carina, into an upper, more or less flattened "shoulder" portion and a lower, generally larger body portion (Fig. 5). Sometimes more than one carina arises, in which case all except the lower portion of the whorl becomes flattened, the section assuming the appearance of a portion of a polygon. The angulation, which finally develops into a carina, and often into a more or less accentuated "keel," is generally due to the strengthening of one of the primary spirals above the others. When the shell is ribless the angulation becomes a smooth keel. This feature appears early in the pleurotomarioid shells, in which the angulation is generally accompanied by an emargination or sinus of greater or less depth, which occupies the place of the carina. This group of shells, which appears to be a very heterogeneous one, probably had its beginning in the Lower Cambrian species of Raphistoma, of which *R. attleborensis* Shaler and Foerste is

the representative in the Etcheminian limestones of the Atlantic coast region. That this species is derived from the round-whorled *Straparollina remota* of the same horizon seems probable on comparison of the species, and this is in line with the theoretic consideration which derives the angular-whorled forms from more primitive round-whorled species.

When the angulation appears far down on the whorl, so that the suture of the next whorl touches it, a trochoid shell is produced, which varies in outline from the gently tapering form of many Cerithiums, etc., where the basal angle is very obtuse, through the flat-based Trochus, where the angle is strongly acute, down to Xenophora with concave base and overhanging lateral margins, where the acuteness of the angle is extreme.

When the angle is relatively far up on the whorl, so that the body portion is the largest, we have again two types of spires produced. When the succeeding whorl joins the earlier one *below* the angle, a turreted or terraciform spire is produced, in which the length and slenderness of the spire depends on the amount of the embracing of the whorls and the obtuseness of the shoulder angle. The long graceful spire of *Fusus toreuma* and its near allies is a result of a pronounced slope of the shoulder, together with a very moderate degree of embracing of the whorls, or what might be called a slender coiling. The strong contraction of the body of the whorl below the angle accentuates the slenderness of the spire, producing what is generally called a depressed suture. In some other species of Fusus all these features are less accentuated, and the spire as a result becomes more condensed and relatively stouter, thus losing some of its gracefulness. In other gastropod shells we can study all degrees of condensation of the spire owing to the increased embracing of the whorls, the flattening of the shoulder even to right angles with the axis of the spire, and the assumption of a cylindrical form by the body of the whorl. When the later whorls embrace the preceding ones up to the shoulder angle, a uniformly sloping trochoid spire is produced, the degree of slope of which depends on the angle which the shoulder makes with the longitudinal axis of the spire. Thus we may have every gradation from the long slender spire of certain

pleurotomoid shells to the perfectly flattened or even slightly sunken spire of certain species of Conus. In this latter genus it is perceptible that even in the most flattened species the young whorls form an elevated spire, which varies in intensity of slope in different individuals. The flattened or sunken condition appears only in the later stages.

A type of modification of the whorl, which at least in appearance belongs here, is due to the formation of a notch in the

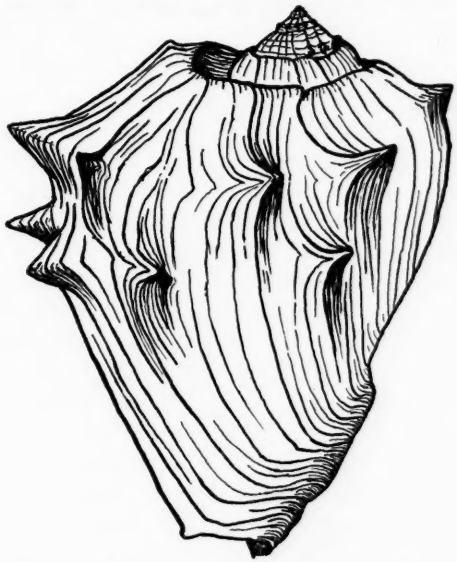


FIG. 9. — *Melongena melongena*. An immature individual, showing the melongenoid growth and the spines. Slightly reduced.

posterior margin of the aperture of the shell, where the body whorl joins the preceding one. This feature has so far been found only in the old-age stage of the individual, or in the adult or even earlier stages of phylogerontic types, *i.e.*, such as belong to a declining group of gastropods. This posterior notch may cause a transgression of the final portion of the last whorl on the spire, thus covering up a portion of the preceding whorls. This is generally accompanied by a resorption of previously formed spines or other ornamentation which would

interfere with the comfort of the animal. Accompanying the formation of this notch is generally a change in the outline and ornamentation of the last whorls, as will be discussed further beyond. This type of structure is well shown in *Melongena melongena* (Fig. 9) and *M. patula* of the modern tropical seas, and may well be termed a "melongenoid" type of growth. A striking modification of this type is seen in Strombus, where it appears only in the adult and is accompanied by the formation of a lip, and by fingers in pteroceroids.[1] This may be termed a "stromboid" type of growth. It appears periodically in Cassis, where it has the value of varices. An extreme type, the "cypræoid," is seen in Cypræa and Ovulum, where the spire is entirely covered in the adult. Still another type, characteristic of the Eocene Clavilithes and related genera, is produced by the flattening of the top of the posterior canal and the production of a flat sutural shelf, which however is unaccompanied by an increase in the amount of embracing of the whorls. This shelf thus runs like a regular spiral path around the spire part way, in rare cases almost all the way, up to the apex. This type deserves to be specified as the "clavilithoid" type of growth. In extreme cases it spreads out laterally into a flange, which in certain species is broken up into blunt, vertically flattened spines (Fig. 18).

One of the most pronounced modifications of the aperture is the formation of an anterior notch at the point most distant from the apex. This notch which lodges, and is due to the formation of an anterior mantle fold which serves the purpose of a siphon, is in many specialized types drawn out into a long slender canal, which finds its most perfect development in Fusus and in certain Murexes, where it is occasionally transformed into an almost closed tube, from the apposition of the upper borders. This type of modification makes its appearance in the Ordovician genera Subulites and Fusispira, where, however, the canal is more suggested than actually developed.

Ornamentation of the Whorls. — The simplest types of what for want of a better term we may call ornamentation of the

[1] From unpublished studies on Strombidæ, by Miss I. H. Ogilvie, it appears that the Pterocera has a polyphyletic origin.

whorls are, as already suggested, simple ribs, or spirals, or both. When the whorls remain round throughout the life of the individual no other regular ornamentation is as a rule produced, except that in the final (gerontic) portion of the last whorl the ribs, and in some cases the spirals, may disappear, leaving the shell smooth. If, however, a shoulder is produced through the formation of an angulation, a new succession of ornamental types will arise, which generally appears in the same sequence in widely separated groups of gastropods. The first effect of the angulation seems to be to concentrate the growth force on it. The ribs become accentuated on the angle, and correspondingly fainter away from it. Finally, they disappear above and below the angle, being represented on the latter, however, as a series of tubercles. These tubercles, though generally blunt, may at times assume a somewhat spinous form ; but they appear to be distinct from true spines, which, so far as observed, are a feature of later growth. In the cases in which actual succession has been traced out in series (Fulgur, Fusus, Hemifusus, etc.) it was found that the knobbed or tuberculated stage is succeeded by a stage in which the tubercles become confluent, producing a pronounced ridge or keel on the angulation. This after a time disappears, and with it the angulation, the outline of the whorl becoming rounded again, with only the spirals persisting. These in some cases may disappear also, or at least become very faint. After the whorl has returned to its primitive rounded outline a new type of modifying element arises in the form of spines. These begin as notches in the margin, generally in the spiral zone of the angulation of the earlier whorls, but sometimes in a second or even a third zone lower down on the body of the whorl (*e.g.*, Melongena). They mark a distinct and periodic fold in the outer lobe of the mantle, which sometimes is accompanied by a temporary cessation in shell building, as indicated by more or less strongly marked resting lines in the lines of growth of the shell (*Fulgur carica*, etc.). They thus have all the characters of varices of the type so pronounced in Murex, where their multiple development and frequent compound character produce the most striking feature of the group of shells generally associated

under that generic name. When the spine has been fully developed, the fold in the mantle which caused it may gradually diminish in size, with the active resumption of the shell-building process, until it finally disappears. In this case the spine is gradually closed on the apertural side, thus becoming symmetrically developed (Fulgur, Hemifusus). In some cases, however, the fold of the mantle appears to be lost abruptly when the shell-building process recommences. In such cases the apertural side of the spine remains open, becoming entirely external by the flooring over of the emargination produced by the spine in the shell margin. This type is most characteristic of the spines forming the varices of Murex.

Through a process in acceleration in development, which will be more fully discussed below, the spines may be crowded backwards, *i.e.*, appear earlier and earlier, thus condensing the preceding stages more and more until finally some of them are dropped out altogether. Thus it will eventually happen that as in *Fulgur carica* of the recent fauna the keeled and smooth stages are dropped and the spines follow immediately upon the tubercles, and to some extent even encroach on these. A gradual passage from the true tubercles to the true spines is thus produced, and it becomes practically impossible to determine where one type ends and the other begins. This feature may be readily observed in the various species of Hemifusus, in most of which varieties occur showing all stages from the widely separated tuberculated and spinous stages to those in which spines and tubercles grade into each other without allowing a line of demarcation to be drawn. In trochoid and other shells in which the whorls embrace up to the angulation, the spines, if present, are either imbedded in the succeeding whorl and more or less covered up, or else they are progressively resorbed as the new whorl increases. In Melo and some other genera the spines project upwards and are generally unclosed on the apertural side. This produces the spiral "corona," so striking a feature in some shells. Finally, the remarkable apical character of *Yetus* (*Cymbium*) *proboscidialis* should be mentioned. In this a depressed, smooth, central, apical area occurs, due to a secondary deposit which covered

up all the preceding whorls. This is margined by a sharp elevated and thin edge.

Varices. — Varices are the periodic rows of spines, or the reflexed or bent-over lips which mark recurrent stationary periods in growth in many gastropod shells. Several types may be recognized, — the spinous, *e.g.*, Murex, the simple reflexed lip, best shown in Scalaria, and the periodically accentuated normal rib, perhaps the most abundantly represented type. The simplest type of the spinous varix is that in which each stopping place is marked by only one simple spine. Such a condition, found in Fulgur and a number of other genera, is generally not considered as falling under this category ; but it is clear that the multispinous varix is a modification of the unispinous one. This becomes more apparent when we note that in every multispinous varix one of the spines predominates over the others to a greater or less extent. On tracing back the spiral from which this spine arises, which is generally possible, even though the lower spines are progressively resorbed by the advancing inner lip of the new whorl, it appears that in every varix it bears the largest spine. Finally, on tracing back far enough, only one spine is seen on the whorl, — the primary spine, which throughout is recognizable by its predominant size. In *Murex brassica* Lam. of the west Mexican coast we have a type in which only a few additional small spines occur besides the primary large spine. This is but slightly advanced beyond the state found in Fulgur. In *M. bicolor* the shell continues to grow somewhat after the chief varix is formed, the principal spine alone remaining unclosed, so that the lip at the resting stage differs little from that of Fulgur. The multispinous type of varix, with simple spines, is best illustrated in the beautiful *Murex tenuispira* Lam., the most striking in form of all the Murexes. Each spine arises from a spiral line, of which it forms the apertural prolongation. The shorter spines arise from the secondary spirals, and on the canal they are bent at about 120° forward from the primary ones, thus lying parallel to the primary series of the next but one varix preceding. Only in the neighborhood of the large spine do the tertiary and even later cycles of spirals terminate in small spines.

If the spine from a primary spiral does not increase in length rapidly, but increases in width, the secondary and later spirals, instead of developing independent spines, encroach upon the primary one and modify it by the production of lateral crenulations, which, as the spine grows, diverge more and more and become more and more pronounced, until the striking multilobed character of the spine of *M. palma-rosæ* (Lam.) and other highly ornate species is attained. If the principal spine of such a species is traced backward through preceding varices (which can generally be done, since resorption does not reach up to it), it will be found to be less and less complex in earlier and earlier varices, and ultimately may perhaps — in a very perfect specimen — be resolved into a single spine. (See Fig. 10.) In the growth of the spine itself, from its beginning on the final or first varix (counting backward) to its full development, as already noted, it progressively increases in complexity. A stage somewhat earlier than the adult stage in this spine shows the same degree of complexity as the *adult* of the representative of this spine in the next preceding or second varix. A still earlier stage in the principal spine of the first varix corresponds to the stage just preceding the adult in the principal spine of the second varix, and to the adult stage in the corresponding spine of the next earlier or third varix, and so on. In the same manner, though less perfectly developed in most cases, the spine next below (anterior of) the principal spine on the final or first varix has the characters of the adult of the principal spine in the next preceding or some earlier varix, and the third spine has the adult characters of the principal one in a still earlier varix. The last spine of the final varix — presumably the last formed one — has the characters of the principal spines in one of the earliest varices, when the shell was still very young (Fig. 10, where *A-10* corresponds to *K-1*, and *B-10* to *L-1*). Thus each spine passes through a succession of stages, and in its reappearance in a new varix it has made marked advances. The life history, therefore, of a single spine may be read by noting the characters of all the spines of that varix progressively from the smallest to the largest. This also indicates in general the life history of the group to which the

species under consideration belongs. Thus in an ancestor of *M. palma-rosæ* we might expect that the principal spine on the last formed varix of the adult shell would have the characters of this same spine in an earlier varix in *palma-rosæ* or those of a more anterior spine in the adult varix of that species. Such correspondence of characters in localized areas (*e.g.*, a single varix), with the changes characteristic of the life history of the group, has been called by Jackson the formation of localized

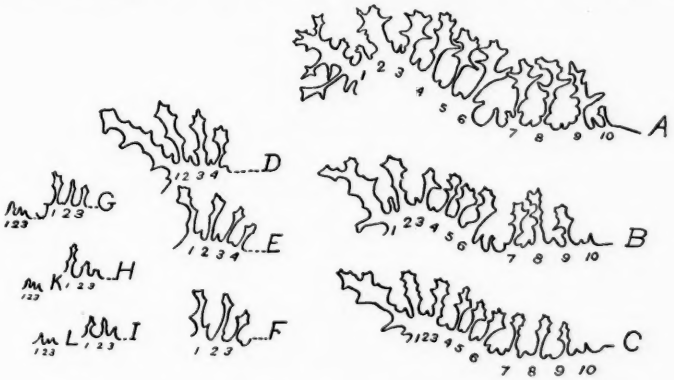


FIG. 10. — Diagram of the varices of *Murex brevifrons* Lam., from the West Indies. *A* is the last or most recent varix, *L* the earliest recognizable one. The corresponding spines are numbered alike. The dotted line indicates that the remaining portion has been resorbed.

stages in development, and he has found this phenomenon in a great many types of animals and plants.[1]

One of the commonest types of varix is that due to accentuation of normal ribs. Even in the spinous Murexes the bases of the spines are merged in such an accentuated rib, which recurs with greater or less frequency, though with regular periodicity, in the various species. This accentuated rib, whether spinous or not, appears to mark the periodic culmination of constructive vitality, after the expenditure of which a rest is necessary before building again commences.

The varices of Harpa are due to a periodic reflection of a smooth lip, which has the appearance of a margin rolled back.

[1] Jackson, R. T. Localized Stages in Development in Plants and Animals, *Mem. Boston Soc. Nat. Hist.*, vol. v, No. 4.

In Scalaria the varices are simple labial flanges, which stand out as sharp ridges, with the appearance of ribs. In *Helix albolabris* and other types the varix is formed only in the adult. In all types with successive varices it may be observed that the varices of the same longitudinal zone do not form a line parallel to the axis of the shell, but that this line runs spirally backward, in the direction opposite to that in which the whorls coil (Fig. 12). This is due to the fact that there is a progressive diminution in the proportional amount of building which was performed between the resting stages. If the amount of building were proportional to the size of the shell, the varices would run in straight, constantly diverging lines (Fig. 11) instead of spiral ones. If the proportional increase were too great for the size of the shell, and progressively increasing, the lines of varices formed by the corresponding ones of all the whorls would pass spirally forward, *i.e.*, in the direction of coiling of the shell. Neither this nor the case of increase proportional to the size of the shell has been noted, and it hence appears that we have here an illustration of Minot's law of senescence, the animal progressively growing old from the beginning. This feature is best shown in Scalaria, where in large specimens an additional feature, first pointed out to the writer by Prof. R. T. Jackson, is also seen. This is the more rapid shortening of the building stages, in the old age of the individual, so that the varices of the last — old age — whorl are not continuous with those of the preceding ones but fall between them, so that sometimes a varix may be the whole length of a period behind what it should be (Fig. 13). In phylogerontic species of Scalaria this feature appears in the adult or earlier whorls,

FIG. 11. — Diagram illustrating hypothetical varix growth, with uniform proportional increment.

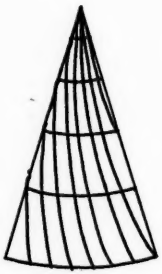


FIG. 12. — Diagram of the characteristic retarded growth between varices.

which whorls will then have a larger number of varices than those preceding them.

Other Ornamental Features.—Dall[1] has demonstrated the purely mechanical origin of the columellar plication in gastropod shells to be due to the sliding inward and outward over the columellar surface of a mantle lobe folded by being crowded into too small a space. In Cypræa these plications are most numerous and developed in the adult on both sides of the aperture. The intensity of the plications varies with the nearness or remoteness of the muscle of fixation. In a like manner the liræ of the outer lip may be explained. We must, however, be careful not to mistake the strong spirals, which sometimes appear through the thin covering of the inner lip, for plications, or the interspiral spaces appearing prominently in the thin outer lip, for liræ. Countess von Linden has discussed at length the development of the color pattern in gastropods,[2] and the reader is referred to her paper.

FIG. 13.—Diagram illustrating gerontic characters in the varices of the last whorl.

Individual Old Age, and Phylogerontic Characters in Gastropods.—Gerontism, or old age, is marked in its earlier stages in gastropod shells by the disappearance of features characterizing the adult. Such disappearance of features is generally in the reverse order in which they were formed. In the fusoid types the shoulder and the spines are the first to be lost, if they have been developed; or if there were only spinous tubercles, as in the Fusidæ, these disappear together with the angulation, and the gerontic lip becomes smooth except for the spirals. The normal outline is next more or less modified by an attempt at straightening out the whorl and making it more cylindrical,

[1] *Loc. cit.*, p. 58.

[2] von Linden, Maria. Die Entwicklung der Skulptur und der Zeichnung bei den Gehäuseschnecken des Meers, *Zeitschr. für wissensch. Zoologie*, Bd. lxi, pp. 261–317. 1 pl.

producing a consequent obscurity of the canal. The last stage in gerontism is observed in the loss of the power to coil, which is at first expressed in the separation of the inner lip from the columella; and if any further coiling occurs, in the loose apposition of the whorls and the consequent formation of an umbilicus. These features never go very far in the normal gerontic individual, for death intervenes and ends the process.

Among the highly specialized types of gastropods uncoiled phylogerontic species are relatively uncommon. Perhaps the most striking example in a highly specialized group in which such a want of regular coiling does exist in the adult is Vermetus. This, as is well known, has all the characters of a Turritella in its young stages, showing its derivation to be from that group. In the adult, however, it loses the power to form a regular spiral, turning and twisting in all directions and completely uncoiling at times, so as to make these portions of the shell almost indistinguishable from worm tubes such as Serpula. In primitive gastropods non-coiling, through the loss of the power to coil, appears to be the normal expression of old age, or gerontism, since in most cases the coil is the only feature which can be modified.

Shells with the final portion of the coil unrolled are well represented in the Ordovician. They even occur in the Cambrian, as indicated by *Platyceras primævum* Billings from the Lower Cambrian. From what is known of this little shell it appears that it represents a strongly umbilicated, low-spired naticoid type, with a portion of the last whorl free. If, as appears to be the case, the early whorls are normally coiled, and only the later coil loosely, this little shell represents the first phylogerontic type appearing side by side with the naticoid radicle of the entire group of gastropodous mollusks. Leaving out the loose coiling Eccyliomphalus and Eccyliopterus as of questionable affinities, the first well-pronounced example of a phylogerontic type with the final whorls not coiled is found in the Ordovician pleurotomarioid genus Lophospira. This genus, which comprises mainly normally coiled umbilicated forms, contains a few species which have become phylogerontic and show various degrees of non-coiling (Fig. 14).

Trochonema vagrans Ulrich and Scofield (Fig. 15), from the Stones River group, represents a phylogerontic type among the carinated naticoid gastropods, while *Dyeria costata* (James), from the Upper Lorraine of Cincinnati, represents a phylogerontic type of the group of simple naticoid shells with depressed spire. In the Silurian, *Platyostoma* (*Diaphorostoma*) *niagarensis* frequently shows individual gerontism by a loose outer lip. *Platyceras niagarense* represents a phylogerontic type, possibly derived from the former. In the Devonian the phylogerontic non-coiling Platycera abound. We find all degrees of coiling, from the close-coiled non-umbilicate Diaphorostoma, which appears with slight modifications throughout most of the series, to the straight "Orthonychia," which appears as a terminal member in most groups. Very often a number of species of "Platyceras" can be traced to a species of Diaphorostoma or Strophostylus occurring with them, the gradations being perfect. From such evidence it appears that the numerous species classed together as Platyceras must be split up into groups, each of which has been derived from a close-coiled ancestral species, probably within the same geological horizon. If so, the name Platyceras becomes meaningless for generic purposes. The great difficulty which besets the proper breaking up of what appears most certainly to be a group of polyphyletic origin lies in the small number of ornamental characters which can be made use of in tracing out relationships. In many Platycera spines appear, but these cannot be regarded as clues to affinity, since spinous types may and do arise in any group. What seems to be the right method of procedure was made use of in the

FIG. 14. — *Lophospira helicteres* var. *wisconsinensis* A. and S., showing loose coiling. (After Ulrich, *Palæontology of Minnesota*, vol. ii, pl. lxxii, Fig. 26.)

FIG. 15. — *Trochonema vagrans* U. and S., illustrating gerontic final whorl. (After Ulrich, *Palæontology of Minnesota*, vol. ii, pl. lxxviii, Fig. 13.)

determination of the genetic relation of *Platyceras arkonense* Shimer and Grabau, from the Hamilton of Ontario.[1]

Natica neritæformis, from the European Muschelkalk (Queenstedt), as far as can be judged from the internal molds which are alone represented, is a phylogerontic member of a simple naticoid group of shells. Fissurella, Acmæa, and other patelloid types, so common in the Mezozoic and modern sea, have, as already noted, a coiled protoconch. They therefore represent phylogerontic types, in which the power of coiling has been lost after the completion of the protoconch stage. In Crepidula the power to coil is still retained in a slight degree. In the majority of specialized gastropods phylogerontism is expressed, not in the non-coiling of the last portion of the spire, but in its expansion and wrapping about the earlier whorls so that these become more or less concealed. This is generally accompanied by the loss of all ornamental characters except, in some cases, the coloration. Sometimes it happens, however, that spines arise independently on this portion of the shell. This is most marked in Melongena and can be readily explained by the peculiar manner in which the shell develops.

In the young stage every typical Melongena has the characters of Hemifusus. In accelerated species of this genus spines follow the tubercles, the two grading into each other as in *Fulgur carica*. In other species, however, notably *H. colosseus* Lam. and *H.* (*Melongena*) *pugilinus*, a keeled or even smoothly rounded stage intervenes between the tubercled and spinous stages. (See *ante*.) This enables us to understand Melongena.[2]

The two typical species of this genus appear to have been derived from the same ancestral species, which coexists with

[1] Shimer, H. W., and Grabau, A. W. The Hamilton Group of Thedford, Ontario, *Bull. Geol. Soc. Am.*, vol. xiii, p. 176.

[2] Only the two typical species, *Melongena melongena* and *M. patula*, are referred to here. Most of the other species generally referred to this genus belong elsewhere. Such species as *M. morio* and *M. pugilina* are transitional from typical Hemifusus, *e.g.*, *H. colosseus* Lam., being produced chiefly by a condensation of the typical Hemifusus characters. They are generally classed with Melongena, but have not the typical phylogerontic growth of that genus. They will be referred to under both names.

them, — namely, *Hemifusus* (*Melongena*) *morio*. Representatives of this species occur in both west African and West Indian waters. From the west African type appears to have been derived the Mazatlan species *Melongena patula*, while *M. melongena*, at home in West Indian waters, was derived from the West Indian representative of *H.* (*M.*) *morio*. In both species the phylogerontic melongenoid form of whorl appears immediately after the tubercled and before the spinous stage, this latter coming in somewhat later. Thus, while the mode of coiling has become senile, the formation of the spines indicates

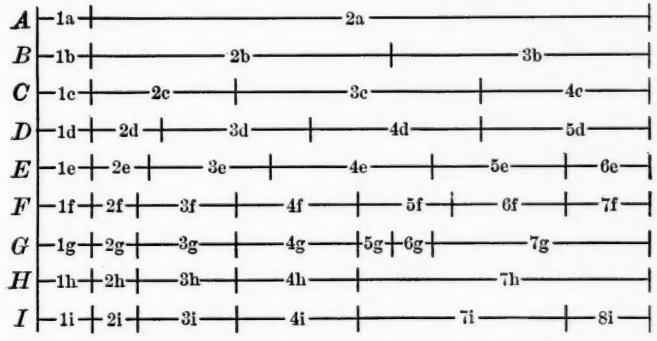


FIG. 16. — Diagram illustrating Hyatt's Law of Acceleration in Development. For description see text.

the persistence of one portion of the vigor of the adult. Such form of acceleration may be called partial or incomplete, differing in that respect from Fulgur, in which the acceleration is complete. A reason for this may perhaps be found in the following consideration: Fulgur is an accelerated type in the present fauna. The species in which a separation existed between the tubercles and spines all lived in Miocene and Pliocene times, and hence in the modern descendant (*F. carica*) spines have become firmly established. We may further suppose that the power to form spines has persisted so long that in the adult it is on the wane; and hence if any phylogerontic types of Fulgur should arise, the spines would first disappear and probably would never be formed again. In Hemifusus, on the other hand, the spine-forming power has

apparently been but recently acquired, judging from the frequent lateness in appearance of spines in individuals. Thus there would be more vitality or spine-forming power left, which would be able to overcome any weakening effect of senility appearing in other features of the group. Hence, though a gerontic form of coiling is assumed by the whorls of Melongena, the power to form spines is still retained, and these appear after an interval in the senile portion of the whorl.

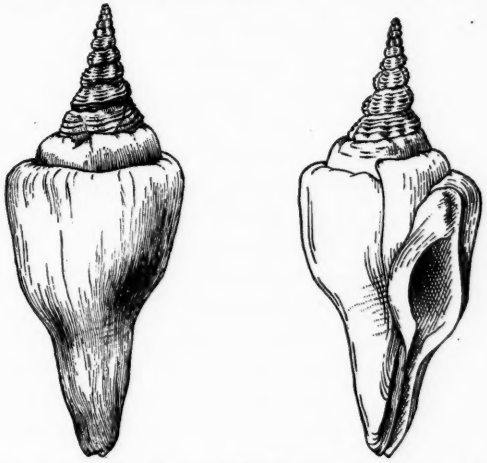
Illustrations of the Law of Tachygenesis and of Parallelism among Gastropoda. — Hyatt's Law of Tachygenesis, or acceleration in development, teaches us that the adult characters of a species are inherited at an earlier stage in the members of a succeeding generation. This of course implies a condensation of preceding characters, which in some cases may even be dropped entirely. The diagram on page 941 (Fig. 16) will give a clearer representation of the working of this law.

Let each of the lines *A* to *I* represent the life history of an individual gastropod in a phylogenetic series, beginning with *A*. Let the life history be divided into stages numbered from 1 up, each stage being characterized by some definite feature in the shell.

No. 1 is the protoconch stage, which persists throughout; No. 2, the smooth, round, whorled naticoid stage; No. 3, the primitive ribbed and spiraled stage; No. 4, the angular stage, with formation of nodes at the crossing of the ribs; No. 5, the keeled stage; No. 6, the second round-whorled stage; No. 7, the spinous stage; No. 8, the spineless smooth stage.

It becomes apparent that as new characters appear, the older ones persist for a shorter and shorter time. This is necessary, for otherwise each succeeding species must be larger to accommodate the new characters. This is acceleration by condensation. A character newly acquired in one member of the series appears earlier and earlier in the succeeding members of that series, thus changing from an adult to an infantile character. Some characters are less resistant than others, and these will be more quickly condensed. Such is the case with those of stages 5 and 6, the keel and the second round-whorled stage. The nodes are very persistent, and the

spines (of stage 7) are very vigorous. Thus it will happen, as in *H*, that stages 5 and 6 are dropped out altogether, stage 7, the spinous one, following upon stage 4, the tubercled



FIGS. 17 and 17 *a*. — *Cyrtulus serotinus* Hinds. Recent. A phylogerontic type of the Fusus series. Natural size.

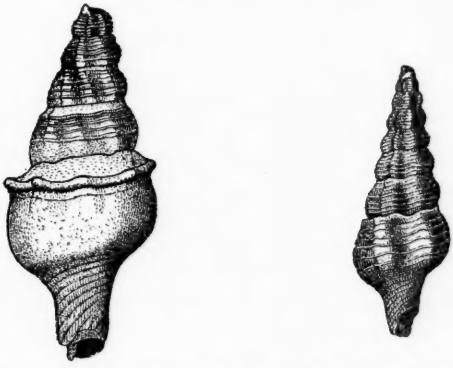


FIG. 18. — *Clavilithes chamberlaini* Johnson and Grabau. Eocene. Texas. Two stages; the adult showing a serrated flange and clavilithoid form. (*Proc. Phil. Acad. Nat. Sci.*, September, 1901.)

one, and even encroaching upon it. This is acceleration by elimination (example: *Fulgur carica*). Finally, even the vigorous spines disappear, and the final smooth gerontic stage is formed.

Parallelism. — There are perhaps few if any classes of invertebrates which equal that of the Gastropoda in illustrating the law of parallelism of development. In the Gastropoda similar features constantly arise independently in entirely distinct series; and since these features are generally used as a basis of classification, it follows that our present system of classification is in great need of revision. If we represent the natural system of classification by the customary tree and its branches, and then pass a more or less warped plane through the upper part of this tree, intersecting each branch at the same relative stage of development, we obtain a number of scattered points where the plane and the branches intersect. If we consider these points species, and group all the neighboring and perhaps some distant points into genera and so on, we will get very much what we have to-day in the classification of marine gastropods. In point of fact, we have only one episode in each of the large number of distinct phyletic series, and what we mistook for relationship is only a resemblance in a parallel developing series which has been cut at the same stage in development. Thus it is clear why the customary mistake of placing the recent *Cyrtulus serotinus* (Figs. 17, 17 *a*) with its parallel, the Eocene Clavilithes, is so generally made. Both are phylogerontic members of entirely distinct phyletic series, but they have reached the same stage in development. Again Fusus, known only in the Eocene of Europe, and in this country only from the Miocene on, has its close parallel in Pseudofusus and other genera in the American Eocene. Here the same type of form is developed, — a very simple matter, — but, as shown by the life history, the two types are widely apart genetically. Again, all gastropods with stromboid lips are placed with Strombus, a proceeding which has no warrant from a phyletic point of view. The common proceeding of classing all loose coiled or non-coiled Paleozoic gastropods under Platyceras has likewise no warrant from a phyletic view point, though it must be confessed that this is a convenient method when we do not know what else to call them. Thus, without multiplying examples, we may sum up the result of our studies in the words of Hyatt's Law of Morphogenesis: "A natural classification

may be made by means of a system of analysis in which the individual is the unit of comparison, because its life in all its phases, morphological and physiological, healthy or pathological, embryo, larva, adolescent, adult, and old (ontogeny), correlates with the morphological and physiological history of the group to which it belongs (phylogeny)."

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THE OCCURRENCE OF FORMICA CINEREA MAYR AND FORMICA RUFIBARBIS FABRICIUS IN AMERICA.[1]

WILLIAM MORTON WHEELER.

In a valuable paper published in 1886[2] Dr. Gustav Mayr recorded both *Formica cinerea* and *F. rufibarbis*, two well-known European ants, as occurring in the United States. The former was cited from California and New Mexico, the latter from Colorado, Nebraska, California, and Montana. Seven years later, when Professor Emery published his important revision of the North American Formicidæ,[3] he was so doubtful of the occurrence of these forms in the United States that he did not include them in his synoptic table. Concerning the former species he wrote: "*F. cinerea* does not occur in North America; the form identified as such by Mayr will be described below as *F. pilicornis* n. sp." In regard to *F. rufibarbis* his statements are less positive: "For the present I am inclined to doubt whether forms belonging to the true *fusco-rufibarbis* series are actually indigenous to America. I am really unable to distinguish from rather pale and very pilose European *fusca* (*fusco-rufibarbis*) only three workers which were received from Colorado through Mr. Pergande. The precise locality of these specimens is not given."

More than a year ago Dr. Harold Heath of the Leland Stanford University sent me numerous specimens both of *F. cinerea* and *F. rufibarbis* which he had kindly collected for me near San Jose, California. The *F. rufibarbis* was compared with

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, No. 38.

[2] Die Formiciden der Vereinigten Staaten von Nordamerika, *Verhand. Zool.-Bot. Ges. Wien.*, Bd. xxxvi (1886), pp. 419–464.

[3] Beiträge zur Kenntniss der nordamerikanischen Ameisenfauna, *Zool. Jahrb.*, Abth. f. Syst., Bd. vii (1893), pp. 633–682, Taf. XXII, and Bd. viii (1894), pp. 257–360, Taf. VIII.

European specimens by Professor Emery, who reported as follows (*in litteris*): "It is the true European form, differing from our common type only in the total absence of erect hairs on the thorax. In this respect it approaches var. *glauca* Kusgky from Oriental Russia." It is possible that Dr. Mayr may have seen specimens of this same ant, but it is more probable that he had specimens of *neo-rufibarbis* Emery, a common form throughout the more western and southwestern states as far as the Pacific coast. The specimens of *cinerea* received from Dr. Heath were compared with European *cinerea* given me by Professor Emery, Professor Forel, and Dr. Mayr. The specimens from Professor Emery were collected near Bologna, Italy. They are decidedly smaller and have a darker ground color than the Californian specimens. These, however, agree very closely in their larger size and somewhat reddish coloration with the Austrian and Swiss specimens from Dr. Mayr and Professor Forel. I believe, therefore, that there can be no doubt concerning the occurrence in California of two species of Formica almost or quite identical with the European *cinerea* and *rufibarbis*. It is not so easy to decide whether one or both of these species are imported or indigenous to the American continent, but I know of no cogent reasons for accepting the former alternative. Certainly the occurrence of these species on the Pacific coast and their apparent absence from the eastern states of our Union are extremely suggestive in connection with the like geographical distribution of many other Pacific coast arthropods (Astacus, *e.g.*, many Diptera, and other insects) which are known to be more closely related to European genera and species than to those of the Atlantic states.[1]

After accustoming myself to view the distribution of the two species of Formica in this light, I was much surprised during August of the past summer to find *cinerea* very abundant in the vicinity of Rockford, Winnebago County, Ill. For several weeks of three successive summers I had collected very diligently without finding any such species in this locality. It

[1] See, *e.g.*, Osten Sacken's "Western Diptera." Cases in point are also the Californian ants of the subgenus Messor, and *Myrmica mutica* Emery, which is hardly more than a subspecies of the European *M. rubida*.

occurs most commonly, however, in such peculiar situations that there is little difficulty in understanding why it has been so long overlooked. The formicaries are so large and populous that it can hardly be regarded as an imported species unless it resembles some of the European weeds which have found the American soil so very favorable to their growth and expansion.

The following account of the localities in which I have taken *F. cinerea*, together with some notes on the structure of its formicaries, may prove to be of interest to students of insect distribution in general and of our American Formicidæ in particular. There are three of these localities some ten miles apart, in different directions and at least three to five miles from the town of Rockford, and in each of these localities, which are all open and exposed to the full heat of the sun, the nests are of a different type. August 20, I found a single nest, the first I had seen, under a small log in a meadow. This nest was not very populous and contained neither larvæ nor pupæ. It consisted of several inosculating galleries of the type usually made by species of Formica and extended down at least to a distance of 20 cm. into the black, waxy soil. The ants were timid, like the inhabitants of all small nests of Formica, and made no attempt to attack me. August 22, I found two very large nests side by side at the edge of a turnpike not far from a meadow. Each of these covered an area of somewhat more than a square meter, and each consisted of a flat mound of earth about 10 cm. high, strewn with little straws and sticks brought together by the ants. This débris concealed numerous openings from which the ants rushed forth as soon as the nest was disturbed. Excavation was difficult on account of the hardness of the soil, but it was easy to make out that the formicary consisted of a honeycomb of galleries 1–2 cm. in diameter and extended down into the soil to a depth of more than 30 cm. It was filled with worker larvæ and pupæ, together with thousands of ants, which attacked me furiously, using their jaws and formic acid batteries to good purpose. August 25, I discovered a locality where there are hundreds of *cinerea* nests. This is a meadow about a mile and a half long

and a quarter of a mile wide, surrounded by woods and corn fields. It is traversed by a cool stream, the banks of which for some distance on either side are boggy and thickly studded with large grass-covered hummocks. The *F. cinerea* have constructed their formicaries in these hummocks, which range from 30 cm. to 60 cm. in diameter at the base and from 20 cm. to 30 cm. in height. There are nests in nearly all stages of growth, but for the most part well-established and extremely populous, being, with the exception of the two nests above described, the most populous nests of Formica I have seen during the entire summer. The formicary is started in the summit of the hummock, but ultimately invades its whole earthy substance and extends to a depth of at least 30 cm. to 60 cm. into the black soil from which the hummock arises. In small or moderately large nests all the grass which originally covered the hummock remains intact and in excellent condition, but in the largest formicaries the grass on the summit is partly cut away by the ants and partly buried under the earth brought up from the galleries and the little straws, bits of twigs, leaves, etc., collected by the insects in obedience to an instinct which appears to be shared to a greater or less extent by all the species of Formica. This makes the large nests very conspicuous, although the numerous openings, all in the flattened or somewhat convex summit of the hummock, are hidden under the outermost layer of vegetable débris. The living grass forming the sides of the hummock gives the nest great stability and very efficiently protects it from being injured by the feet of the pasturing cattle. Excavation of larger nests shows that the hummocks are honeycombed throughout with a network of inosculating galleries abruptly terminating at the level of the moist, black meadow soil, into which only a very few long and more or less perpendicular galleries and chambers penetrate to a depth of 60 cm. and possibly farther.[1]

[1] During September, after this paper had been sent to the *Naturalist*, I happened on a fourth locality abounding in *cinerea* nests. This was a large meadow almost within the city limits of Rockford. It contained formicaries of all three types: under logs and stones, in the form of flat, irregular mounds and in modified hummocks.

These peculiar hummock formicaries occupy a zone on either side of the stream midway between the dryer and more boggy portions of the meadow, although a few of them reach quite to the edge of the stream and are even perforated by the burrows of frogs. The nests are so numerous as to be often within a meter's distance of one another. Along the outer edges of these zones, and mingled with the dryer *cinerea* nests, there are occasional nests of *F. subsericea* of precisely the same structure. The main zone of this species, however, lies on higher ground, where the hummock nests are replaced by true mound nests entirely constructed by the ants.[1]

There were some slight variations in size and coloration among the *F. cinerea* found in different nests in this locality, but these are all comparable to similar variations in European specimens. On the whole, the specimens from Illinois have the ground color of the head and thorax more or less reddish like the Californian and Austrian specimens. All the individuals examined have a number of hairs on the lower surface of the head. According to Emery this is the distinguishing trait of *cinerea* among all the European Formicidæ. In the United States *F. schaufussi* and *F. subpolita* and its varieties agree with *cinerea* in possessing such hairs, but they may be

[1] As Father Muckermann has shown in a recent paper (The Structure of the Nests of Some North American Species of Formica, *Psyche*, June, 1902, pp. 355–360), *F. subsericea* makes nests of at least four different styles: small flat moundlets in the grass with numerous apertures, nests in mounds capped with pieces of rock or wood, small nests beneath stones, and finally large mound nests. According to Father Muckermann the nests of the style last mentioned are neither as large nor of the same shape as those of *F. obscuripes* and *F. exsectoides*. This is true in general, but I have seen at the edges of fields in the environs of Milwaukee, whole colonies of grass-covered *subsericea* nests varying from 30 cm. to 1 in. in diameter and from 20 cm. to 30 cm. high, dimensions almost as great as those recorded by Father Muckermann for *obscuripes*. I may say in this connection that, like Father Muckermann, I do not altogether agree with Forel, who believes that the American are inferior to the European ants in mound building. As contradicting such a view, I would point to the large formicaries of *F. exsectoides* in the eastern states, to those of different varieties of *F. rufa* in different parts of the United States, to the species of Pogonomyrmex and Ischnomyrmex in the West and Southwest, and to the yellow species of Lasius (*L. aphidicola*, *claviger*, and *interjectus*) in Illinois. During the past summer I saw near Rockford a dome-shaped formicary of *L. interjectus* 1.5 meters in diameter at the base and 60 centimeters high, and I have seen many nests of this and the other yellow species of Lasius that were fully one-half to two-thirds as large.

readily distinguished by their coloration, which is never ashy or silvery gray. At first sight *F. subsericea* resembles *cinerea*, but the former never has hairs on the lower surface of the head. This character definitely separates the two forms, notwithstanding the fact that *subsericea* presents color variations in the direction of *cinerea*.[1]

The *cinerea* nests were not seen till it was too late in the year to secure the winged sexes, which, like the males and females of our other species of Formica, probably make their appearance during June and July. Even the dealated mother queens were found in but one of the smaller nests. All the nests, however, were full of worker larvæ and pupæ. The latter were generally enclosed in cocoons, but quite a number of nude pupæ were also seen in many of the nests. In this respect *cinerea* resembles the Formicidæ of the *pallide-fulva*, *fusca*, and *subpolita* groups, the worker larvæ of all of which, in contradistinction to *F. rufa* and its varieties, have a very pronounced tendency to omit spinning a cocoon just before pupation. At Rockford during the past summer many of the nests of these species contained only nude pupæ. This may have been due to the great amount of moisture in the nests, as June and July were unusually rainy. At any rate, I observed that the cocoons were relatively much more abundant during the dry weather late in August.

In its habits *F. cinerea* is very similar to the ants of the *fusca* group. It was seen in great numbers visiting the flowers in the meadow and attending great droves of Aphidæ on the willows along the stream. The walls of the galleries in some of the formicaries were tenanted by teeming colonies of the minute lestobiotic, or thief ant, *Solenopsis molesta* Say. In one *cinerea* nest I took a myrmecophilous histerid beetle (*Hetærius brunnicipennis* Randall).

ROCKFORD, ILL., September 1, 1902.

[1] At Rockford I discovered two rather large nests of a form which should, perhaps, rank as a distinct variety of *F. fusca* allied to *subsericea*. The ants from these nests are smaller and more graceful in stature than the common *subsericea*, the legs and antennæ are red like those of *cinerea*, and the body is so thickly overlaid with silvery white, appressed pubescence that the black ground color is hardly visible. This form may be called *Formica fusca* var. *argentata* var. nov.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XII. The Trematodes.

PART II.— THE ASPIDOCOTYLEA AND THE MALACOCOTYLEA, OR DIGENETIC FORMS (continued).

H. S. PRATT.

Key to the Species of North-American Aspidocotylea and Malacocotylea, so far as described.

Genus Stichocotyle.

Larva found in *Nephrops norwegicus* and *Homarus americanus:* length 3–7 mm., with 7–22 suckers. Adult in *Raja clavata:* length 17–105 mm., with 20–27 suckers . . . . . *S. nephropis* Cunn. (Fig. 2) (62, 68)

Genus Cotylaspis.

Body white or pinkish: in various species of Unio and Anodonta
C. insignis Leidy (Fig. 5) (22, 23, 73, 16, 17)

Genus Cotylogaster.

Body elongate; anterior portion of body terminated by a five-lobed disk surrounding the mouth; sucking disk with 132–144 depressions; marginal sense organs present; from dorsal surface near posterior end rises a broad conical elevation, at base of which is excretory pore; length 8 mm.: in gut of sheepshead in Minnesota . . . . . *C. occidentalis* Nick. (66)

Genus Aspidogaster.

Number of depressions about 64; sucking disk elliptical, covering two-thirds of the body: in pericardium, liver, and kidney of Unio and Anodonta
A. conchicola v. Baer (Fig. 7) (20, 22, 23, 16, 17, 78)

Genus Paramphistomum.

a_1. Body ovoid or elliptical.
  b_1. Acetabulum large; testes 2, lobate, in median line; 12 mm. long, 5 mm. wide: in intestine of Manatus
P. fabaceum Dies. (32)

b_2. Acetabulum emarginate; 4–24 mm. long, 2–12 mm. wide: in intestine of terrapin . . . . . *P. grande* Dies. (29)

a_2. Body conical or subconical.

b_1. Acetabulum large and subterminal; testes lobate, median: in stomach of sheep and cattle . *P. cervi* Zed. (Fig. 9) (85, 87)

b_2. Acetabulum in ventral surface not quite at posterior end, emarginate; genital pore near anterior end often in a papilla or retracted in a depression; body triangular in cross section: in the muskrat *P. subtriquetrum* R. (45)

GENUS DIPLODISCUS.

Acetabulum large; body tapering anteriorly: in intestine of frogs *D. subclavatus* R. (Fig. 12) (21, 80, 79, 41)

GENUS FASCIOLA.

a_1. In mammals; worms of large size.

b_1. Worms 18–50 mm. in length, 4–13 mm. in breadth; anterior end distinctly set off from remainder of body; broadest part of worm in front of its middle: in cattle, sheep, deer, man, *et al.* *F. hepatica* L. (Fig. 13) (83, 85, 93)

b_2. Worms 20–100 mm. long, 11–26 mm. broad; anterior end indistinctly set off; broadest part of worm back of its middle; body flesh colored: in cattle . . *Dist. hepaticum* Curtice (83)
Dist. carnosum Hassall (83)
Dist. americanum Hassell (83)
Dist. texicanum Francis (83)
Dist. crassum Leidy (83)
= *F. magna* Bassi (83, 85, 93)

a_2. In birds; worms not of large size; body piriform; 14 mm. long: in lungs of kingfisher . . . . . *Dist. trapezium* Leidy (32, 81)
= *F. reticulata* R. Wr. (97, 44)

GENUS FASCIOLOPSIS.

Body nearly circular; 15 mm. long, 12 mm. wide; in liver of an Indian elephant (in Boston) . . . . . *F. jacksoni* Cob. (Fig. 14) (83, 44)

GENUS PLEORCHIS.

Body linguiform; 14½ or 15 pairs of testes present; 5.25 mm. long, 1.5 mm. wide: in lung of a turtle (*Sternotherus odoratus*) *P. mollis* (Leidy) S. et H. (82)

GENUS PARAGONIMUS.

Body red in life; suckers small; ovary to left of acetabulum; 8–20 mm. long, 4–8 mm. wide: in lungs of cat and dog, *et al.*, and possibly encysted in the muscles of swine (Agamodistomum *sp.*) in a larval condition *P. westermanni* Kerb. (Fig. 17) (93, 87)

GENUS OPISTHORCHIS

a_1. Body not spinose, lanceolate; testes not at extreme hinder end of body; 10–21 mm. long, 1–2.5 mm. wide: in the liver of cats and the cayote . . . *O. pseudofelineus* Ward (Fig. 30) (94, 81, 93)

a_2. Body spinose, very elongate; testes at extreme hinder end of body; 12–29 mm. long, 1 mm. wide: in liver of crow
O. spesiosus S. et H. (81, 84)

GENUS METORCHIS.

Uterus massed around acetabulum; body linguiform; testes large and lobate; 6 mm. long, 2 mm. wide: in cats
M. complexus S. et H. (Fig. 32) (81)

GENUS TELORCHIS.

Yolk glands extend in front of acetabulum; intestinal cœca extend beyond testes; 3.15 mm. long: in intestine of painted turtle
T. angustus Stafford (79)

GENUS DEROPRISTIS.

Anterior end usually attenuated and covered by large, coarse spines, remainder of body by short spines; acetabulum much larger than oral suckers; 3–6 mm. long, 1.2 mm. wide: in the intestine of *Phycis tenuis*
D. hispidus Abil. (40, 70)

GENUS ECHINOSTOMA.

a_1. Number of oral spines usually 37; 18 mm. long, 1.5 mm. wide: in intestine of muskrat . . . . *E. echinatum* Zed. (Fig. 25) (28)

a_2. Number of oral spines 45; 2.5 mm. long: in intestine of *Œdemia americana* . . . . . *E. flexum* Linton (36)

a_3. Number of oral spines 27; body elliptical; 8 mm. long: in intestine of *Botaurus minor* . . . . . *E. aspersum* R. Wr. (97)

GENUS STEPHANOCHASMUS.

a_1. Number of oral spines 32, 16 being in each row; body cylindrical anteriorly, globose posteriorly; 2.5–3 mm. long: in capsules in peritoneum of filefish (*Alutera schoepfii*) *et al.*
S. valdeniflatus Stoss. (38, 40)

a_2. Number of oral spines 42, 21 being in each row; body slender or lanceolate; pharynx very large; prepharynx long; intestinal cœca wide; 3 mm. long, 0.6 mm. wide: in rectum of striped bass (*Roccus lineatus*) . . . . . *S. tenuis* Linton (38, 40)

a_3. Body elongate; pharynx large; prepharynx long; 3.15–4.5 mm. long, 0.5 mm. wide: in peritoneum of white perch (*Morone americana*)
S. tenuis tenuissimus Linton (38)

a_4. Body elongate; 4.5 mm. long: in intestine of *Cottus scorpius*
S. sobrinus Lev. (33)

a_5. Number of oral spines about 48, 24 being in each row; body broad, lanceolate; testes and ovary in contact with each other; 1.14–1.85 mm. long, 0.37–0.64 mm. wide: in intestine of flounder (*Paralichthys dentatus*) . . . . . *S. dentatus* Linton (39, 40)

GENUS RHOPALIAS.

Body elongate, tapering towards the hinder end; tentacles long, being up to 1.3 mm. in length; prepharynx and œsophagus of about same length; 6–9 mm. long, 0.8–1.16 mm. wide: in intestine and stomach of opossum (*Didelphys virginiana*) . . . . . *R. coronatus* R. (80, 7)

SUBFAMILY PSILOSTOMINÆ.

a_1. Body subcylindrical, anterior end cylindrical and very contractile, without spines; acetabulum larger than oral sucker; prepharynx, pharynx, and œsophagus present; yolk glands very voluminous and extend from acetabulum to posterior end, filling the body behind the testes, but not in front of acetabulum; 0.88–1.42 mm. long, 0.25 mm. wide: in intestine of hake (*Merluccius biliniaris*) *et al.*
Distomum vitellosum Linton (39, 40)

a_2. Body elliptical, depressed, anterior end cylindrical, contractile, without spines; yolk glands extend from pharynx in front of acetabulum to hinder end, usually not overlapping the intestinal cœca; prepharynx, pharynx, and œsophagus present; 1.6–2.74 mm. long, 0.57 mm. wide: in intestine of flounder (*Paralichthys dentatus*)
Distomum pudens Linton (39, 40)

a_3. Body elongate, linear, spinose; yolk glands extend from acetabulum to hinder end of body; prepharynx, pharynx, and short œsophagus present; 3 mm. long, 0.55 mm. wide: in intestine of cod
Distomum rachion (Cob.) Linton (38)

a_4. Body elliptical or piriform, covered with flat scalelike spines; acetabulum of same size as oral sucker in middle of body; ovary to right of and near acetabulum; yolk glands voluminous, extending from pharynx in front of acetabulum to hinder end of body, filling it back of testes; prepharynx, pharynx, and œsophagus present; 0.26–0.36 mm. long, 0.12–0.18 mm. wide: in pyloric cœca of rudder fish (*Palinurichthys perciformis*) *et al.*
Distomum pyriforme Linton (39, 40)

a_5. Body elliptical; acetabulum larger than oral sucker; anterior dorsal surface papillose; prepharynx, pharynx, and œsophagus present; yolk glands voluminous, occupying hinder half of body; 3.10 mm. long, 0.86 mm. wide: in intestine of filefish (*Alutera schoepfii*)
Distomum pallens (R.) Linton (38, 40)

a_6. Body elongate, without spines; acetabulum prominent, larger than oral sucker; yolk glands voluminous, back of acetabulum; 18 mm. long, 0.34 mm. wide: in intestine of tomcod (*Microgadus tomcod*)
Distomum simplex (R.) Linton (38, 40, 33)

a_7. Body elliptical, spiny; a pair of groups of ocelli near mouth; acetabulum of same size as oral sucker; testes in oblique plane; prepharynx, pharynx, and œsophagus present; yolk glands voluminous, filling body back of acetabulum; 2–2.5 mm. long: in pyloric cœca of *Cottus scorpius* . . . . . *Distomum oculatum* Lev. (33)

a_8. Body elongate, without spines, anteriorly cylindrical, posteriorly depressed; acetabulum larger than oral sucker, near middle of body; prepharynx, pharynx, and œsophagus present; testes and ovary in median line, close together; yolk glands voluminous, extending from acetabulum to hinder end; 1.78 mm. long, 0.33 mm. wide: in intestine of *Mola mola* *Distomum fragile* Linton (39, 40)

a_9. Body elongate, linguiform; prepharynx, pharynx, and œsophagus present; yolk glands voluminous, filling body back of testes; 4.35 mm. long, 1 mm. wide: in intestine of *Pseudopleuronectes americanus* . . . . . *Distomum globiporum* (R.) Linton (40)

Genus Crepidastomum.

a_1. Papillæ small; body elliptical; acetabulum smaller than oral sucker; pharynx and short œsophagus present; yolk glands voluminous, extending from pharynx to hinder end of body and overlapping intestinal cœca; 1.5–4 mm. long, 0.5–1.5 mm. wide: in rectum of Salmo . . . . . *C. laureatum* (Zed.) Linton (37)

a_2. Papillæ large; body linear, tapering towards hinder end; oral sucker larger than acetabulum, but both large; œsophagus absent; yolk glands extend entire length of body; 1.7–2.2 mm. long, 0.6 mm. wide: in intestine of lake sturgeon (*Acipenser rubicundus*)
C. auriculatum (Wedl) Linton (38)

Genus Azygia.

Body subcylindrical, light flesh color, posterior rounded. Ventral acetabulum $\frac{3}{4}$ line behind oral, $\frac{1}{3}$ line in diameter. Oral acetabulum $\frac{1}{4}$ line. Length 8 lines; breadth posterior $\frac{1}{2}$ line, anterior $\frac{1}{3}$ line. Genital aperture before acetabulum: in stomach of Esox . *A. tereticollis* (R.) Leidy (21)

Genus Renifer.

a_1. Body elliptical; genital pore near left edge of body; 3–4.2 mm. long, 1.1–1.6 mm. wide: in mouth of *Heterodon platyrhinus*
R. ellipticus Pratt (Fig. 53) (77)

a_2. Body elongate; genital pore near median line, but a little to left of it; 3 mm. long, 0.68 mm. wide: in mouth of *Heterodon platyrhinus*
R. elongatus Pratt (77)

a_3. Body broad, piriform; genital pore near median line; 3–4 mm. long; 1.5–2 mm. wide: in lung of *Tropidonotus sipedon*
R. variabilis (Leidy) Lühe (21, 53, 77)

SUBFAMILY RENIFERINÆ.

a_1. Body elliptical; acetabulum smaller than oral sucker; testes small, spherical, in same transverse plane; ovary small, spherical, all three being near acetabulum in center of body; genital pore median, in front of acetabulum; 2.8 mm. long: in intestine of frog
Distomum quietum Stafford (79)

a_2. Body elongate, linear; acetabulum near anterior end; genital pore in front of it; testes spherical, in oblique plane, near middle of body; uterus voluminous, filling hinder part of body; yolk glands between testes and acetabulum; 6 mm. long: in ureter and kidney of *Boa constrictor* . . . . *Distomum horridum* Leidy (18, 21)

a_3. Body elliptical, without spines; acetabulum near middle of body; genital pore close to oral sucker; testes immediately behind acetabulum; 1.8–3 mm. long, 0.8–1 mm. wide: in mouth of *Tropidonotus sipedon*
Distomum aniorum Leidy (32)

a_4. Body elliptical; testes ovoid, in same transverse plane; ovary immediately behind acetabulum, which is larger than oral sucker and in middle of body; excretory vesicle wide and long; 3 mm. long: in intestine of *Cottus scorpius* . . *Distomum furcigerum* Olss. (33)

SUBFAMILY PLAGIORCHIINÆ.

Body elongate, with minute spines; uterus very voluminous; yolk glands a number of roundish masses distributed laterally along the middle region of the body; 2.8–5.5 mm. long, 0.6–1.12 mm. wide: in intestine of *Tylosurus carribæus* . . . . . *Distomum nitens* Linton (38)

GENUS BUNODERA.

Intermediate host the crayfish (Cambarus), in which it is found in cysts in ovary and other organs; 1 mm. long
B. nodulosa Zed. (Fig. 45) (98, 35)

GENUS HÆMATOLŒCHUS.

Acetabulum very small: in lung of frogs
H. variegatus R. (Fig. 55) (20, 21, 97, 79)

GENUS OSTIOLUM.

Acetabulum minute; body elongate; median limb of excretory vesicle very long; 7–11 mm. long, 1.5 mm. wide: in frogs
O. formosum Pratt (Fig. 56) (77)

Genus Gorgodera.

a_1. In urinary bladder of frogs and salamanders; number of testes, 9; form of yolk gland, veriform
G. cygnoides Zed. (Fig. 62) (20, 21, 13, 22, 44)

a_2. Number of testes, 9; yolk glands deeply lobate, in form of a rosette; ovary lobate; 4.6 mm. long: in urinary bladder of *Rana catesbiana*, *R. clamitans*, *R. virescens* . . . . *G. amplicava* Lss. (2, 44)

a_3. Number of testes, 2; ovary veriform; yolk glands elongate and not lobate masses; 10 mm. long: in bladder of *Rana catesbiana*, *R. clamitans*, *R. virescens* . . . . . *G. simplex* Lss. (2, 44)

Genus Microphallus.

Body elliptical; œsophagus very long, intestinal cœca very short; 1.7 mm. long, 1 mm. wide: in intestine of *Amia calva et al.*; intermediate host *Cambarus propinquus* . . . . *M. opacus* Ward (Fig. 75) (92, 94, 74)

Genus Levinsenella.

Body elliptical; œsophagus very long; yolk glands consist of several distinct bodies; 0.5 mm. long: in intestine of *Somateria mollissima*
L. pygmæa Lev. (Fig. 71) (33, 15, 94)

Genus Cymatocarpus.

Body elliptical; intestinal cœca extend about to acetabulum; testes in oblique plane; 4 mm. long: in intestine of newt
C. hospitalis Stafford (79)

Genus Brandesia.

Body elliptical; acetabulum in hinder part; genital pore on left side in anterior half; intestinal cœca short and wide; ovary lobate between them; testes in nearly same transverse plane in hinder half of body; 2.5 mm. long, 1.75 mm. wide: in capsules in pyloris of frog . . *B. arcana* Nick. (64)

Genus Pleurogenes.

Body circular; 3–4 mm. long: in cysts in liver of bullfrog
P. medians (Olss.) Stafford (79)

Genus Gymnophallus.

Body elliptical; excretory crura extending to pharynx; 0.5 mm. long: in intestine of *Somateria mollissima* . . . . *G. somateriæ* Lev. (33, 69)

Genus Cephalogonimus.

Body elliptical; testes and ovary very near the acetabulum; œsophagus very short; yolk glands extend in front of acetabulum; excretory vesicle a

rounded sac into which radial canals extend; 2 mm. long: in intestine of soft-shell turtles (Aspidonectes and Amyda) . *C. vesicaudus* Nick. (65)

GENUS PROSTHOGONIMUS.

Body elliptical; acetabulum larger than oral sucker; 7 mm. long, 2.8 mm. wide: in the white of hen's egg, also in *Buteo lineatus* and *Corvus americanus* . . . . . *P. ovatus* R. (Fig. 61) (34, 80)

GENUS DICROCŒLIUM.

Body elongate, lanceolate; suckers near together; testes lobate, close behind acetabulum; 4–10 mm. long, 1–2.5 mm. wide. "Stated to be frequent in sheep in several western states" (Leidy). "Apparently not in North America" (Stiles and Hassall): in cattle, sheep, man, etc.
D. lanceatum S. et H. (Fig. 82) (21, 84, 85)

GENUS LYPEROSTOMUM.

In *Corvus americanus* . . . . . *L. plesiostomum* v. Linst. (80)

GENUS HEMIURUS.

a_1. Body cylindrical; appendix from a third the length to twice the length of the body; acetabulum much larger than oral sucker; testes not near acetabulum; yolk glands compact or slightly lobate; 0.5–6 mm. long: in stomach and pyloric cœca of marine fishes; intermediate host, copepods *D. pelagicum* Stafford (78)
= *H. appendiculatus* R. (Fig. 90) (39, 33, 55, 76, 24)

a_2. Body fusiform; appendix about a third the length of body; acetabulum larger than oral sucker; testes close to acetabulum; 1.5–3.5 mm. long: in *Macrourus bairdii* . . . . . *H. lævis* Linton (39, 55)

a_3. Body slender, cylindrical; appendix about a third the length of body; acetabulum larger than oral sucker; testes distant from acetabulum; yolk glands lobate; 5.12–5.4 mm. long, 0.75–1 mm. wide: in stomach of *Remora remora* . . . . . *H. monticelli* Linton (39)

a_4. Body slender; appendix about a fourth the length of body; 3.2 mm. long, 0.42 mm. wide: in intestine of *Pomatomus saltatrix*
H. ocreatus (Mol.) Linton (39, 55)

GENUS LECITHOCLADIUM.

a_1. Body slender; appendix long; 8–15 mm. long, 0.7 mm. wide: in *Coryphæna hippurus et al.* . . *L. tornatum* (R.) Linton (38, 40, 55)

a_2. Body slender; appendix long and slender; acetabulum of same size as oral sucker; œsophagus wanting; testes just behind vesicula seminalis; the tubular yolk glands extending into appendix; 10 mm. long, 1.14 mm. wide, length of appendix, 3.6 mm.: in butterfish (*Rhombus triacanthus*) . . . . . *L. gulosum* Linton (40, 55)

GENUS LECITHOCHIRIUM.

Body cylindrical; 2–6 mm. long: in stomach of *Anguilla chrysypa*
L. grandiporum (R.) Linton (38, 55)

GENUS LECITHASTER.

Body fusiform; testes immediately behind acetabulum; 1–1.5 mm. long: in intestine of *Cottus scorpius* *Dist. mollissimum* Lev. (33)
= *L. bothryophorus* Olss. (Fig. 93) (44, 55)

GENUS PRONOPYGE.

Body elongated, elliptical, flattened; 2–3 mm. long: in stomach of *Trichinous lepturus* . . . . *Dist. gastrocolum* Leidy (32)
= *P. ocreata* Mol. et R. (Fig. 92) (81, 55)

GENUS DEROGENES.

Body elongate; acetabulum very large, in middle of body; testes close to acetabulum; 2 mm. long: in stomach of *Cottus scorpius et al.*
D. varicus O. F. Mül. (33, 52)

GENUS PROGONUS.

Body elliptical; acetabulum very large, in middle of body; 2 mm. long: in stomach of *Cottus scorpius et al.* . . *P. mülleri* Lev. (Fig. 84) (33)

GENUS HALIPEGUS.

Body elongated; acetabulum larger than oral sucker, in center of body; 10 mm. long: in Eustachian recesses and mouth of frog
H. ovocaudatus Vul. (Fig. 87) (63, 79, 53)

GENUS ACCACŒLIUM.

a_1. Body cylindrical, "dorsal surface and lateral margins armed with spheroidal tuberculate spines"; "twenty flat spines, more or less, on the inner margin of the oral sucker"; 8 mm. long, 0.72 mm. wide: host? . . . . . *A. contortum* (R.) Linton (Fig. 80) (38)

a_2. Body cylindrical and slender; acetabulum larger than oral sucker and on a long peduncle; testes near center of body; no spines present; yolk glands "in slender, threadlike folds, centrally situated"; 35 mm. long, 1.12 mm. wide: in intestine of *Mola mola*
A. nigroflavum (R.) Linton (38, 39)

a_3. Body cylindrical, without spines; acetabulum twice as large as oral sucker and pedunculate; 14 mm. long, 1.7 mm. wide: in intestine of *Mola mola* . . . . *A. macrocotyle* (Dies.) Linton (38, 39, 40)

a_4. Body cylindrical, slender; acetabulum pedunculate, "consisting of four foliate flaps"; 6–8 suckerlike structures in mid-dorsal line at anterior end of body; 12 mm. long, 1.28 mm. wide: in intestine of *Mola mola* . . . . . *A. foliatum* Linton (38)

ALLIED TO GENUS ACCACŒLIUM.

"Body cylindrical, narrowest in fore part and obtuse behind; ventral bothria larger than mouth and projecting in advance in an extent equal to the body; skin smooth and transparent; yellow intestines and white and brown genitals shining through"; 20–45 mm. long, 0.5–1.5 mm. wide: in intestine of *Mola rotunda* . . . . . *Distomum pedocotyle* Leidy (31)

GENUS CLINOSTOMUM.

Body elongate; intestine with short side projections; yolk glands fill body back of acetabulum; cirrus sac before testes; 6–10 mm. long, 1–2 mm. wide: in mouth of *Ardea herodias et al.*; as young form in cysts in *Lepomis auritus et al.*

C. heterostomum (R.) R. Wr. et MacCallum (97, 56, 6)
Dist. gracile (Dies.) Linton (38, 6)
Dist. aquilæ Leidy (27, 81, 6, 85)
C. gracile Leidy (21, 81, 6)
Dist. galactosomum Leidy (30, 56, 6)
= *C. marginatum* R. (Fig. 101) (6)

ALLIED TO GENUS CLINOSTOMUM.

"Body elongated, elliptical, moderately wider and thicker posteriorly, unarmed." "Mouth subterminal and enclosed with a reniform lip, succeeded by a linear annulus. Acetabulum large, at anterior fourth of body." "Genital orifice at posterior fourth of body." Length 15–20 mm., breadth 3 mm.: in mouth of Alligator . . . . . *Distoma oricola* Leidy (25)

DISTOMIDS OF UNCERTAIN LOCATION IN THE SYSTEM.

PARASITIC IN MAMMALS.

Body elliptical and spinose; acetabulum in anterior half of body; genital pore halfway between it and posterior end of body; pharynx, short œsophagus, and long intestinal cœca present; testes large, obliquely behind one another in hinder part of body; ovary to right of them; 0.65–1.2 mm. long, 0.35–0.64 mm. wide: in intestine of Lepus

Distomum tricolor S. et H. (82)

PARASITIC IN REPTILES.

Body elongate; œsophagus wanting; testes obliquely behind one another in middle of body; ovary near acetabulum at anterior fourth of body; uterus between testes and ovary; yolk glands behind testes; 6 mm. long: in intestine of snapping turtle . . . *Distomum chelydræ* Stafford (79)

Parasitic in Amphibians.

Encapsuled under skin of *Siren lacertina* *Distomum sirenis* Vail. (90)

Body elliptical; intestinal cœca short, reaching to acetabulum; excretory vesicle large, the crura reaching to acetabulum; 0.7 mm. long, 0.45 mm. wide: in thoracic cavity of grass frog and encysted in anterior part of bullfrog . . . . . *Distomum tetracystis* (Gal.) Stafford (79)

Body whitish, oblong, sublinear, narrowed anteriorly; oral sucker larger than acetabulum; 3 mm. long, 0.5 mm. wide: in *Rana halecina*
Distomum retusum (Duj.) Leidy (20, 21)

Parasitic in Fish.

Body elongate; suckers near each other, acetabulum somewhat pedunculate; genital pore in front of latter; 15 lines to 3 inches long, $\frac{3}{4}$ line wide: in mouth of Esox . . . . . *Distomum longum* Leidy (20)

"Body long and narrow, band-like, with ventral disk at anterior fourth; smooth." "Ventral acetabulum about the width of body; oral disk smaller"; 8 mm. long, 0.87 mm. wide: in mouth, throat, and gills of sand pike (*Saurus fœtens*) . . . . . *Distomum ischnum* Leidy (32)

"Body flat, elongated elliptical; echinated between oral and ventral acetabula, which are equal, and the latter one is hemispherical and sessile. Length $2\frac{1}{2}$ to 3 lines, breadth 3-5ths to 4-5ths of a line." In intestine of *Leiostomus obliquus* . . . . . *Distomum incivile* Leidy (21)

"Body ovoid, anteriorly compressed, conical and incurved, posteriorly robust and obtuse." "Acetabulum much larger than mouth." "Genital pore a little in advance and to left of acetabulum, provided with prominent circular lip"; length 1–$2\frac{1}{2}$ lines; breadth $\frac{1}{2}$–1 line: in gall bladder of unknown fish . . . . . *Distomum biliosum* Leidy (23)

Body elongate, oval; 20 mm. long, 6 mm. wide: in body cavity of *Remora remora* . . . . . *Distomum lageniforme* Linton (38)

Body elliptical, without spines; acetabulum larger than mouth; testes in same transverse plane near it; ovary in front of testes; intestinal cœca long; 1.25–6 mm. long, 0.7–2.6 mm. wide: in intestine of *Spheroides maculatus* . . . . . *Distomum vibex* Linton (39)

Body wide and thick, without spines, bluntly rounded at both ends; acetabulum very large; œsophagus short, intestinal cœca long; testes and ovary close together in hinder part of body, the latter in front of former; uterus voluminous, filling body back of acetabulum; genital pore to right of pharynx; 2.75 mm. long, 1.4 mm. wide: in intestine of tilefish
Distomum fœcundum Linton (39)

Body broad, spiny; acetabulum small, in anterior half of body; œsophagus short, intestinal cœca long; testes behind ovary, side by side; genital pore to left of pharynx; 0.7–1.3 mm. long, 0.4–0.64 mm. wide: in intestine of white perch . . . . . *Distomum areolatum* (R.) Linton (39)

"Head compressed oval, convex anteriorly; mouth minute, not bordered. Body compressed oblong oval. Ventral acetabulum immersed between body and head. Length 2½ lines, breadth ⅔ of a line." From the intestine of *Rusticola minor*

Distomum (*Clinostomum*) *dubium* Leidy (21, 6)

"Body elongated, sublinear, depressed, unarmed, transversely rugose, posteriorly attenuate. For about 6.5 mm. back of the ventral sucker the body was filled with the voluminous folds of the uterus"; 20 mm. long, 3.2 mm. wide: in stomach of *Raja lævis*

Distomum veliporum (Creplin) Linton (38)

Body cylindrical, posterior portion larger than anterior; testes side by side, immediately behind acetabulum; 18 mm. long, 4.5 mm. wide: in stomach of swordfish . . . . . *Distomum clavatum* (R.) (21, 38)

PARASITIC IN MOLLUSKS.

Body oval; acetabulum large, in center of body; intestine convoluted, passing to extremity of body; genital orifice halfway between acetabulum and hinder extremity of body; length ½ line, breadth ¼ line: in pericardium of *Helix alternata* and *H. albolabris* (intermediate host)

Distomum helicis Leidy (19, 21)
= *Distomum vagans* Leidy (18)

Body fusiform; suckers large; acetabulum near the middle of the body; oral sucker "with a style inserted in the upper lip"; 0.2 mm. long, .08 mm. wide: in liver of *Ilyanassa obsolata* . . . *Distomum lasium* Leidy (32)

PARASITIC IN CRUSTACEANS.

Body cylindrical; acetabulum larger than oral sucker; 1.25 mm. long; 0.4 mm. wide; in *Apus lucasanus* . . *Distomum apodis* Packard (75)

Body clavate, with a long, narrow tail (a cercaria); 0.25–0.4 mm. long: in muscles, liver, and intestine of Planorbis and Limnæa

Distomum ascoideum Leidy (24)

GENUS SCHISTOSOMA.

Male 4–14 mm. long, 1 mm. wide; female 13–20 mm. long, 0.28 mm. wide: in blood of man and cattle (?)

S. hæmatobium Bilh. (Fig. 107) (85)

GENUS KŒLLIKERIA.

Longer diameter of reniform portion 1.74 mm., shorter diameter 1.09 mm., diameter of neck 0.13 mm.: in cysts in intestinal wall of Spanish mackerel . . . . . *K. filicolle* R. (Fig. 108) (40)

Genus Diplostomum.

a_1. Acetabulum and oral sucker small; special organ of attachment of a large cavity at bottom of a conical projection just back of acetabulum, in the center of which is a short canal leading to the cavity, 3–4 mm. long: in intestine of *Strix nivea et al.*
D. grande Dies. (23, 80)

a_2. Special organ of attachment open; acetabulum and oral sucker small; 1 mm. long, 0.35 mm. wide; a larval form found in cysts in liver of *Pomotis vulgaris et al.* . . . . *D. cuticola* Dies. (21, 38, 80)

a_3. Acetabulum large; oral sucker very small; anterior portion of body longer than hinder portion and not sharply separated from it; special organ of attachment an elliptical depression; 3.5–4.5 mm. long: in intestine of alligator . . . . . *D. pseudostomum* Will.-S. (96)

Genus Polycotyle.

Oral and ventral suckers small; 14 mid-dorsal suckers; 4.5 mm. long: in intestine of alligator . . . . . *P. ornata* Will.-S. (Fig. 110) (96)

Genus Holostomum.

a_1. Body spinose, "divided by a constriction at the anterior third." "Head ovoidal, mouth terminal, round, opening into a cup-shaped pharynx"; 3.2 mm. long, 0.8 mm. wide: in intestine of *Rana pipiens*
H. nitidum Leidy (21)

a_2. Body not spinose; ventral sucker twice as large as oral sucker; ventral projection slit longitudinally into several parts and not extending beyond cup; 4–5 mm. long: in intestine of *Ardea herodias*
H. cornu Nitzsch (21, 80)

a_3. Anterior part of body subglobose, variable, aperture transverse; posterior cylindrical; reproductive aperture terminal, surrounded by a muscular border and with a central conical protractile part; 3 mm. long, 0.8 mm. wide: in intestine of *Circus cyaneus*
H. variabile Nitzsch (Fig. 113) (36)

Genus Gasterostomum.

a_1. Body elliptical; mouth in center of body; 4–6 mm. long: in pyloric appendages of *Cottus scorpius* . *G. armatum* Mol. (Fig. 114) (33)

a_2. Body ovate, being wider anteriorly; mouth towards anterior end; 1.9–2.7 mm. long, 0.92–1 mm. wide: in intestine of *Lobotes surinamensis*
Monostomum orbiculare (R.) Linton (38)
= *G. ovatum* Linton (39)

a_3. Body elongate; mouth towards anterior end; 1.28–2.7 mm. long, 0.21 mm. wide: in intestine of *Sarda sarda*
G. arcuatum Linton (39, 40)

SUBFAMILY PRONOCEPHALINÆ.

Body elongate, lateral margins parallel; reniform projection at anterior end; intestinal cœca long and serpentine; testes lobate at hinder end; 18–25 mm. long, 3 mm. wide: in intestine of *Spargus coriacea*

Monostomum renicapite Leidy (21, 8)

GENUS OPISTHOTREMA.

Body broad, sagittate; testes small, lobate, in same transverse plane, laterad of intestinal cœca; ovary small, in front of testes; 10 mm. long; in Manatus . . . . . *O. cochleare* Leuck. (Fig. 118) (80)

GENUS CYCLOCŒLUM.

Body elongate, attenuate anteriorly; 18 mm. long: in thoracic cavity of Gallinago *et al.* . . . . . *C. mutabile* Zed. (Fig. 119) (26, 80)

GENUS NOTOCOTYLUS.

Body elongate, elliptical; testes in hinder end of body; 7 mm. long: in intestine of *Somateria mollissima et al.*

N. verrucosus Fröh. (Fig. 124) (33)

MONOSTOMIDS OF UNCERTAIN LOCATION IN THE SYSTEM.

Body spatulate, broader posteriorly; oral sucker small; intestinal cœca long; 12 mm. long, 2 mm. wide: in bile ducts of muskrat

Monostomum affine Leidy (23)

Body elongate, elliptical, obtusely angular in front, obtusely rounded behind; 12 mm. long, 2 mm. wide: in stomach of jewfish (*Megalops thrissoides*) . . . . . *Monostomum obscurum* Leidy (27)

Body flat, oblong ovate, narrowing anteriorly, obtuse posteriorly; 6 mm. long, 1 mm. wide: in fresh-water fish

Monostomum spatulatum Leidy (23)

Body ovoidal, anteriorly broad; 2 mm. long, 1 mm. wide: in body cavity of *Rana pipiens* . . . . . *Monostomum ornatum* Leidy (21)

Body elongate, posterior quarter slightly broader; œsophagus very long; intestinal cœca short; genital pore at end of œsophagus in hinder half of body; 1.4 mm. long, .24 mm. wide: encapsuled under skin of *Siren lacertina*

Monostomum aspersum Vail. (80)

Body ovate, spiny; 8 testes, 4 on each side; ovary lobate in front of them; uterus voluminous; 2.3 mm. long: in *Opsanus tau*

Monostomum vinal-edwardsii Linton (40)

Body sagittate; hinder end truncated or concave; testes side by side, at extreme hinder end; ovary lobate, near center of body; 5 mm. long: in swimming bladder of catfish . . . *Monostomum amiuri* Safford (79)

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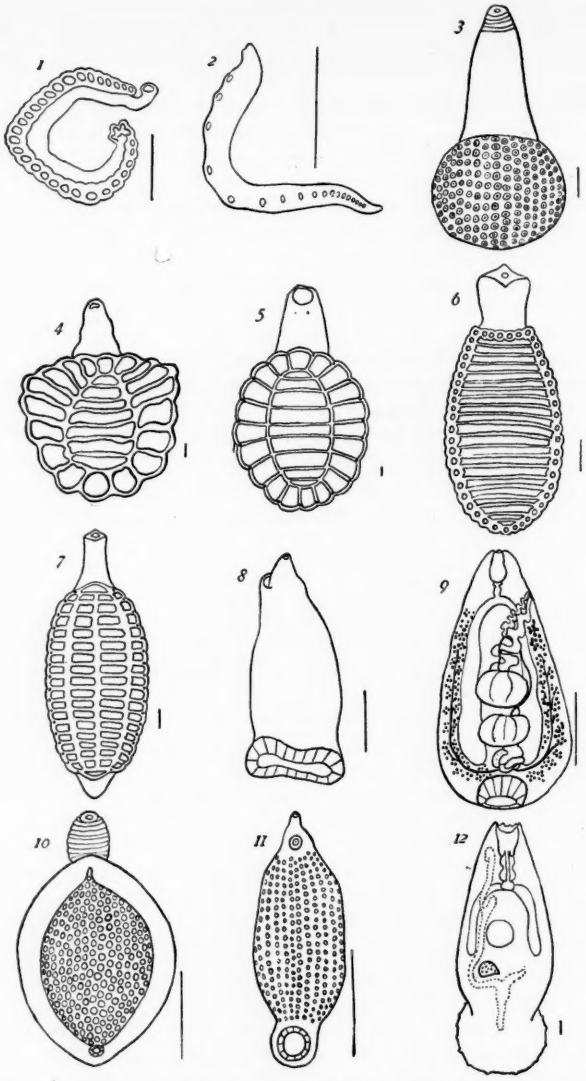

In these figures the ovary, when present, is indicated by being dotted; the receptaculum seminis, by being crossed by parallel lines; the yolk glands, by being solid black. The testes, intestine, and other organs are left white.

FIG. 1. Macraspis elegans Olss., after Monticelli (58). 2. Stichocotyle nephropis Cunn., after Nickerson (62). 3. Aspidocotylus mutabilis Dies., after Diesing from Bronn (3). 4. Platyaspis lenoiri Poir., after Poirier from Bronn (3). 5. Cotylaspis insignis Leidy, altered from Osborn (73). 6. Cotylogaster michaeli Mont., after Monticelli (58). 7. Aspidogaster conchiola v. Baer, after Monticelli (58). 8. Gastrothylax cobboldii Poir., after Poirier from Bronn (3). 9. Paramphistomum cervi Zed., after Laurer from Bronn (3). 10. Gastrodiscus polymastus Leuck., after Lejtényi from Bronn (3). 11. Homalogaster paloniæ Poir., after Poirier from Bronn (3). 12. Diplodiscus subclavatus Goeze, after Walter from Bronn (3).

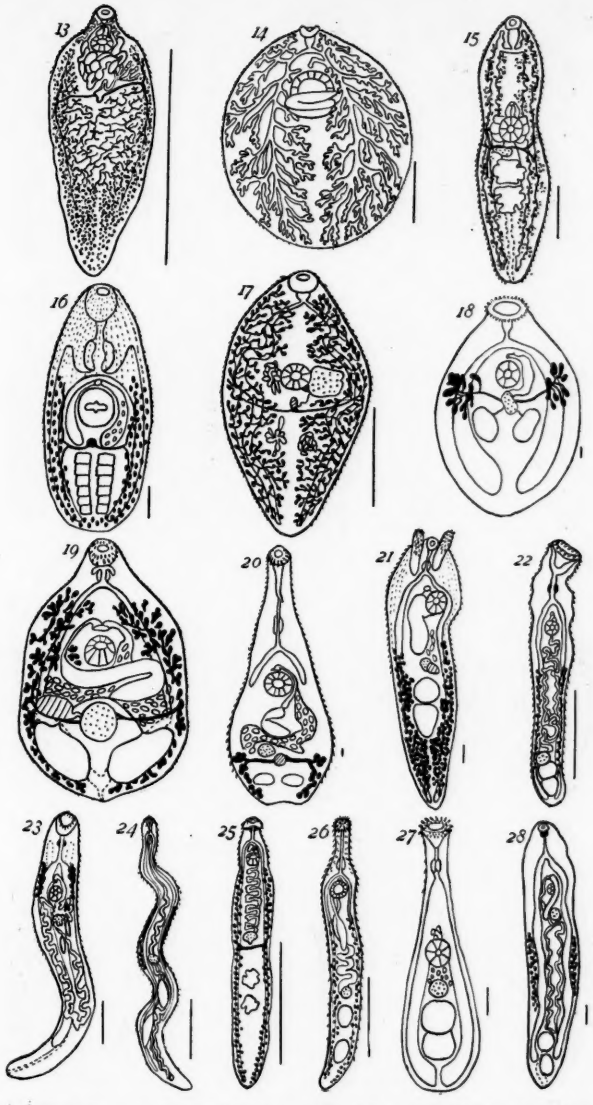

FIG. 13. Fasciola hepatica L., after Stiles (83). 14. Fasciolopsis jacksoni Cob., after Stiles (83). 15. Campula palliata Lss., after Looss from Stiles (83). 16. Pleorchis polyorchis Stoss., after Stossich from Bronn (3). 17. Paragonimus westermani Kerb., after Ward (93). 18. Anoiktostoma coronatum Wag., after Stossich (88). 19. Centrocestus cuspidatus Lss., after Looss (43). 20. Ascocotyle minuta Lss., after Looss (44). 21. Rhopalias horridus Dies., after Braun (7). 22. Acanthochasmus scyphocephalus Brn., after Braun (8). 23. Anisocœlium capitellatum R., after Looss (48). 24. Anisogaster fallax R., after Looss (48). 25. Echinostoma echinatum Zed., after Looss (44). 26. Stephanochasmus cesticillus Mol., after Looss (44). 27. Dihemistephanus lydiæ Stoss., after Stossich and Looss (89, 44). 28. Telorchis parvus Brn., after Braun (8).

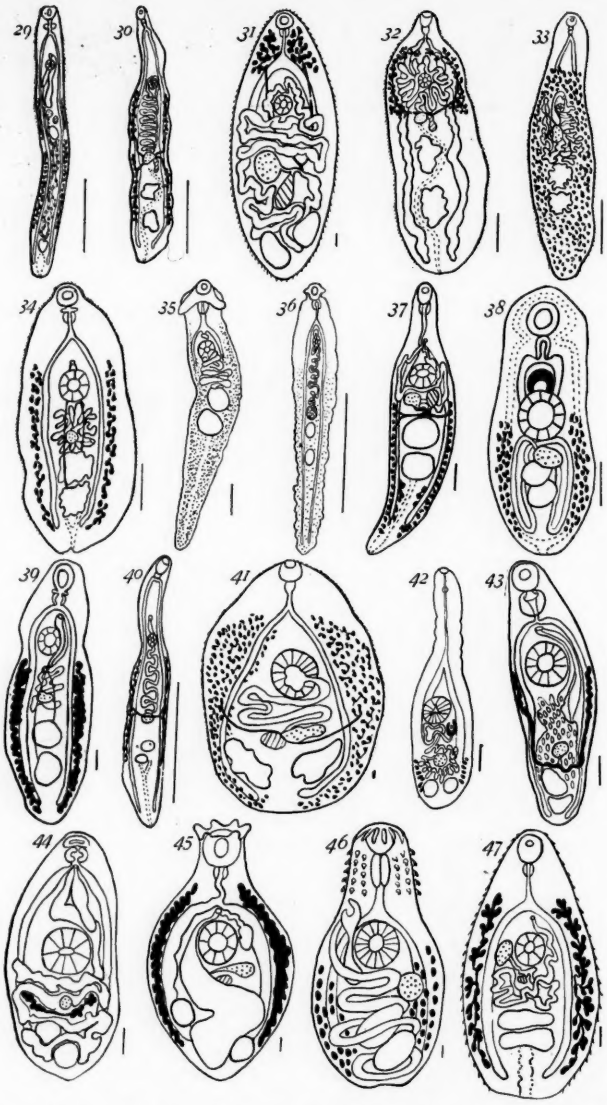

FIG. 29. Orchidasmus amphiorchis Brn., after Braun (8). 30. Opisthorchis pseudofelineus Ward, after Ward (93). 31. Holometra exigua Mühl., after Looss (44). 32. Metorchis complexus S. et H., after Stiles (81). 33. Omphalometra flexuosa R., after Mühling (60). 34. Cathæmasia hians R., after Mühling (60). 35. Calycodes anthos Brn., after Braun (8). 36. Rhytidodes gelatinosus R., after Braun (8). 37. Allocreadium isoporum Lss., after Looss (42). 38. Ptychogonimus megastomus R., after Jacoby (13). 39. Psilostomum platyurum Mühl., after Mühling (60). 40. Azygia tereticollis R., after van Beneden from Bronn (3). 41. Cryptocotyle concava Crep., after Mühling (61). 42. Cotylogonimus persicus Brn., after Braun (7). 43. Philophthalmus palpelabrum Lss., after Looss (44). 44. Pygorchis affixus Lss., after Looss (44). 45. Bunodera nodulosa Zed., after Looss (42). 46. Tergestia acanthocephala Stoss., after Stossich from Bronn (3). 47. Opisthioglyphe endoloba Duj., after Looss (42).

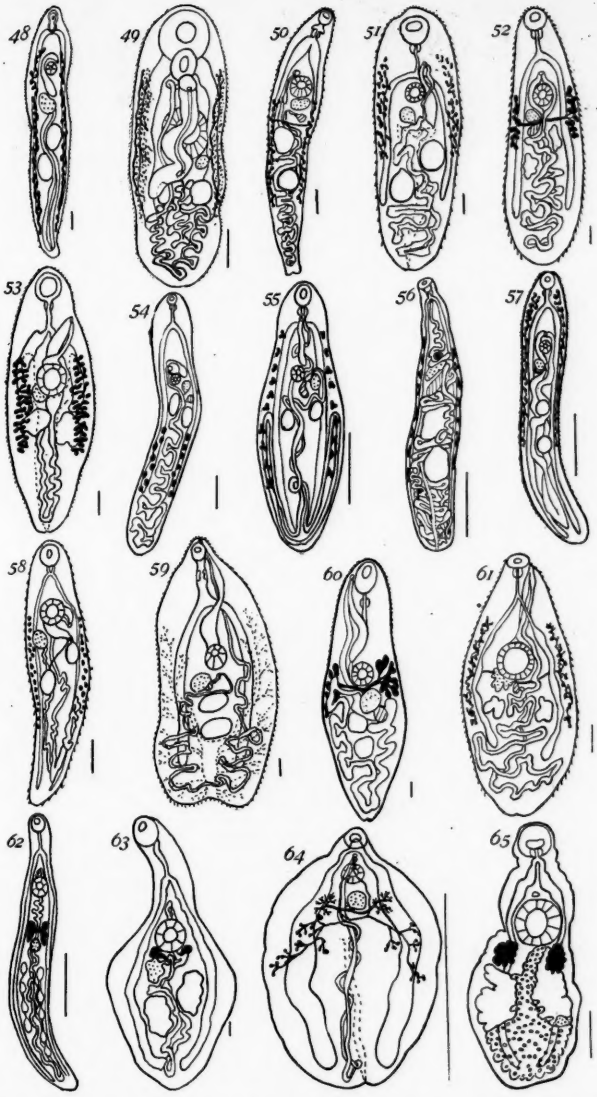

FIG. 48. Plagiorchis cirratus R., after Mühling (60). 49. Pachypsolus irroratus Brn., after Braun (8). 50. Glossidium pedatum Lss., after Looss (44). 51. Astiotrema impletum Lss., after Looss (44). 52. Styphlodora serrata Lss., after Looss (44). 53. Renifer ellipticus Pratt, after Pratt (77). 54. Endiotrema megachondrum Lss., after Looss (44). 55. Hæmatokechus variegatus R., after Looss (42). 56. Ostiolum formosum Pratt, after Pratt (77). 57. Haplometra cylindracea Zed., after Looss (42). 58. Opisthogonimus phylodryochus West, after West (95). 59. Cephalogonimus lenoiri Poir., after Poirier from Bronn (3). 60. Emoleptalea exilis Lss., after Looss (44). 61. Prosthogonimus ovatus R., after Looss (44). 62. Gordodera cygnoides Zed., after Looss (42). 63. Phyllodistomum folium Oef., after Looss (42). 64. Anaporrhutum albidum Ofen., after Ofenheim (67). 65. Plesiorchorus cymbiformis Brn., after Braun (8).

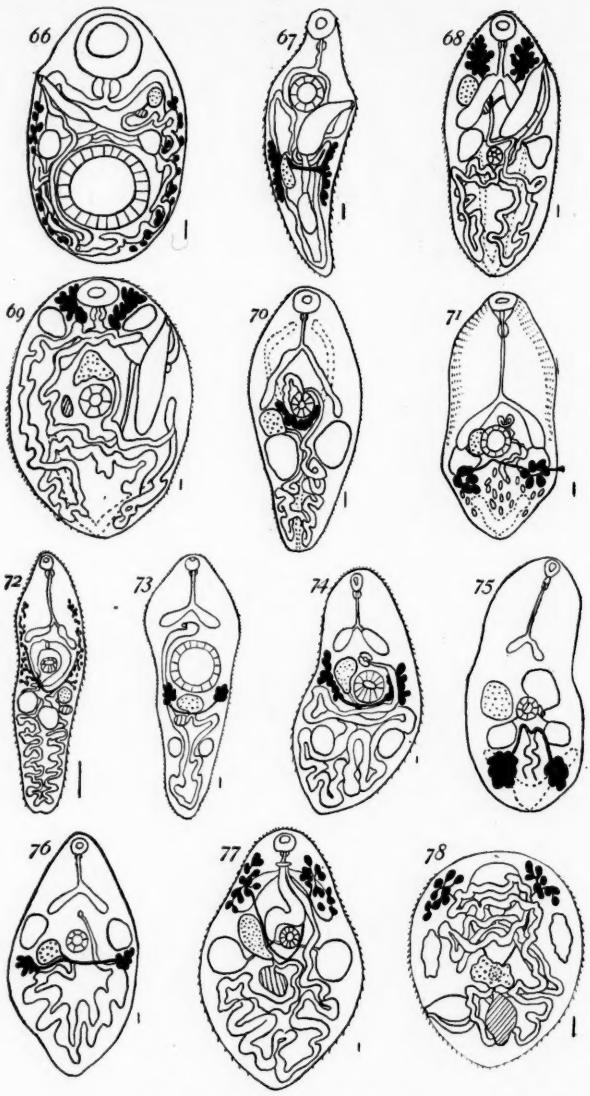

FIG. 66. Stromylotrema singulare Mol., after Looss (44). 67. Asymphylodora perlata v. Nord., after Looss (42). 68. Pleurogenes medians Olss., after Looss (42). 69. Prosotocus confusus Lss., after Looss (42). 70. Gymnophallus deliciosus Odhner, after Odhner (69). 71. Levinsenella pygmæa Lev., after Jägerskiöld (15). 72. Cymatocarpus undulatus Lss., after Looss (44). 73. Brachycœlium heteroporum Duj., after Brandes from Bronn (3). 74. Pycnoporus acetabulus Lss., after Looss (44). 75. Microphallus opacus Ward, after Ward (92). 76. Lecithodendrum ascidium v. Ben., after Looss (42). 77. Phaneropsolus sigmoideus Lss., after Looss (44). 78. Brandesia turgidas Brds., after Looss (44).

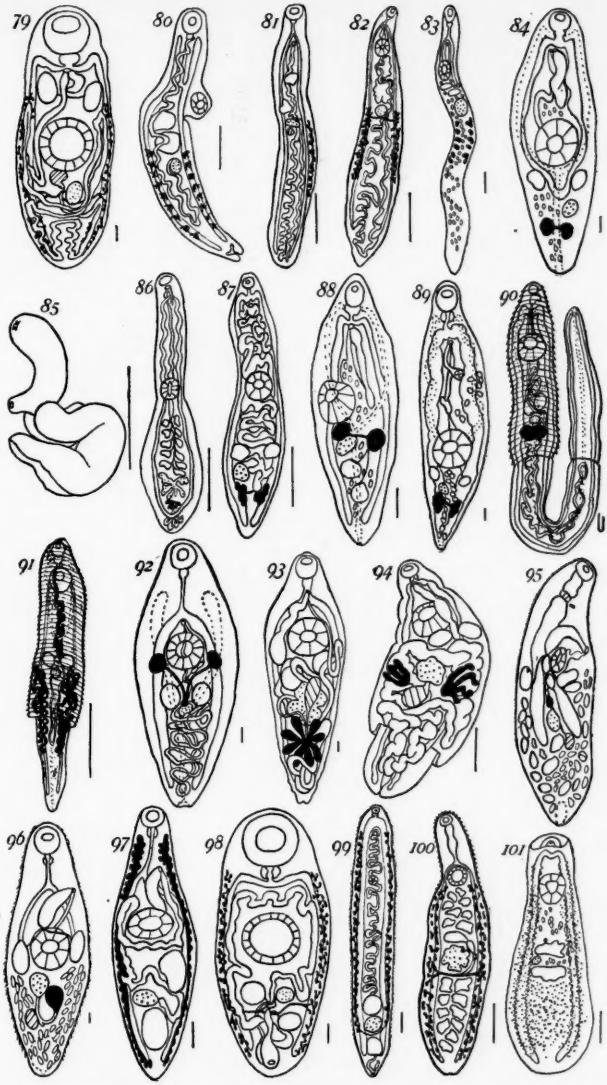

FIG. 79. Eumegacetes triangularis Dies., after Looss (44). 80. Accacœlium contortum R., after Monticelli (59). 81. Athesmia heterolecithodes Brn. 82. Dicrocœlium lanceatum S. et H., after Stiles (81). 83. Lyperosomum strigosum Brn., after Looss (44). 84. Progonus muelleri Lev., after Levinsen (33). 85. Otiotrema torsum Setti, after Looss (44). 86. Syncœlium ragazzi Setti, after Looss (44). 87. Halipegus ovocaudatus Vul., after Looss (42). 88. Liopyge bonnieri Mont., after Monticelli (59). 89. Derogenes minor Lss., after Looss (47). 90. Hemiurus appendiculatus R., after Wagener, altered (91). 91. Lecithocladium tornatum R., after Wagener, altered (91). 92. Pronopyge ocreata R., after Monticelli (57). 93. Lecithaster bothoyophorus Olss., after Levinsen (33). 94. Lecithochirium digitatum Lss., after Looss (44). 95. Zoogonus mirus Lss., after Looss (47). 96. Zoogonoides viviparus Olss., after Odhner (70). 97. Spærostoma globiporum R., after Looss (42). 98. Urogonimus insignis Lss., after Looss (44). 99. Urotocus rossittensis Mühl., after Mühling (61). 100. Hapalotrema constrictum Lear., after Looss (44). 101. Clinostomum marginatum R., after Braun (6).

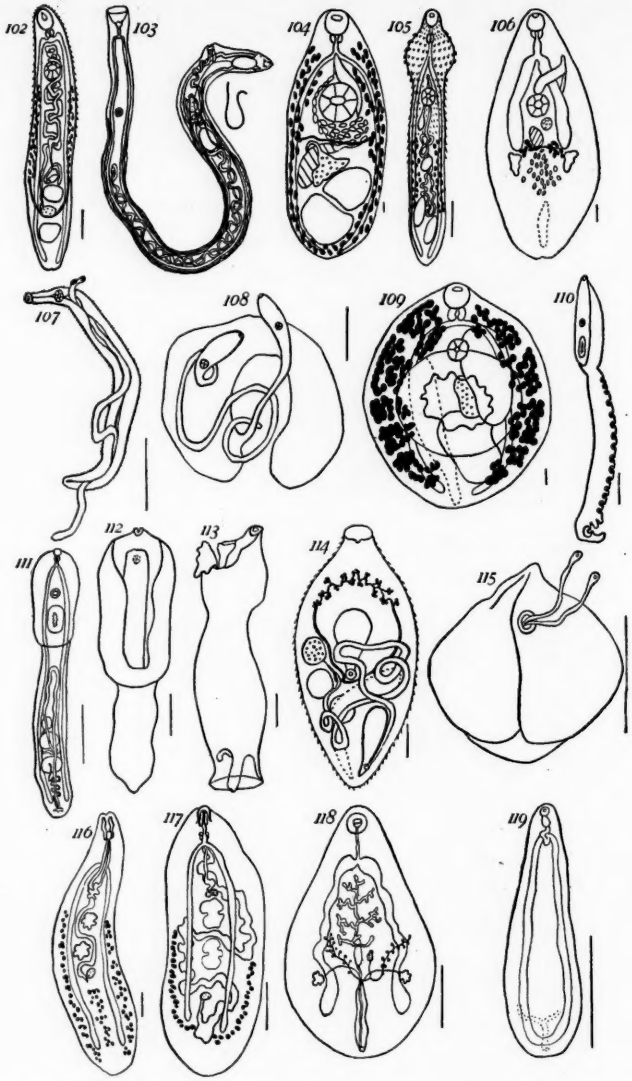

FIG. 102. Harmostomum æquans Lss., after Looss (44). 103. Ityogonimus lorus Duj., after Melnikow from Bronn (3). 104. Halicometra pulchella R., after Odhner (70). 105. Deropristis inflata Mol., after Stossich from Bronn (3). 106. Lepidophyllum steenstrupi Odh., after Odhner (70). 107. Schistosoma hæmatobium Bilh., after Looss (43). 108. Kœllikeria filicolle R., after. Kölliker from Benham (1). 109. Cyathocotyle prussica Mühl., after Mühling (60). 110. Polycotyle ornata Wilh.-S., after Benham (1). 111. Diplostomum longum Brds., after Brandes from Bronn (3). 112. Hemistomum clathratum Dies., after Brandes from Benham (1). 113. Holostomum variabile Nitz., after Benham (1). 114. Gasterostomum armatum Mol., after Levinsen (33). 115. Didymozoon thynni Tasch., after Wagener from Bronn (3). 116. Microscaphidium reticulare v. Ben., after Looss (44). 117. Deutobaris proteus Brds., after Looss (44). 118. Opisthotrema cochleare Leuck., after Fischer from Bronn (3). 119. Cycloccelum mutabile Zed., after v. Ben. from Bronn (3).

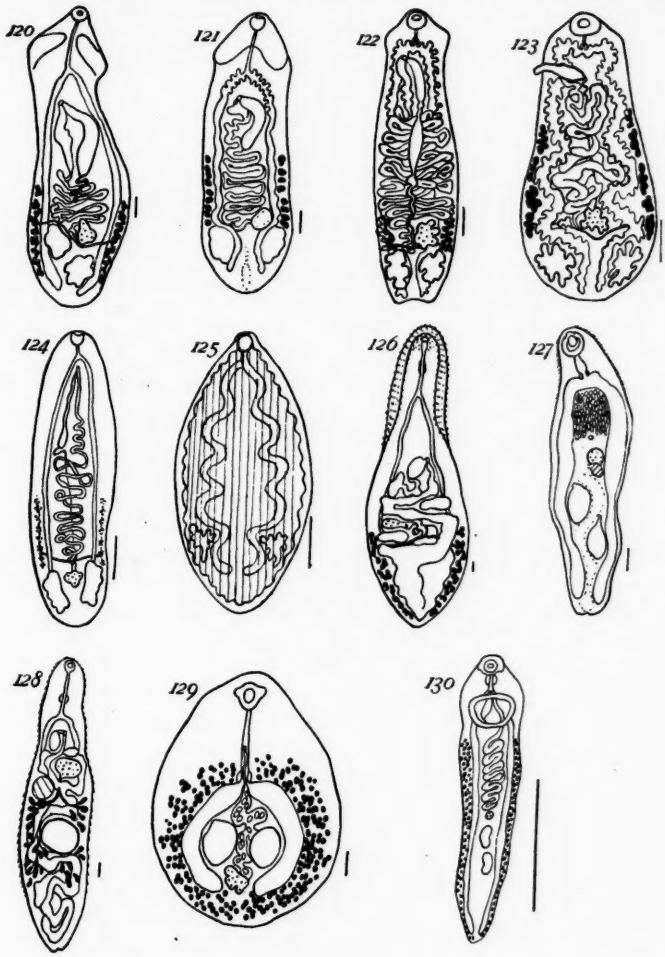

FIG. 120. Pronocephalus obliquus Lss., after Looss (44). 121. Pleurogonius trigonocephalus R., after Braun (8). 122. Cricocephalus delitescens Lss., after Looss (44). 123. Pyelosomum cochlear Lss., after Looss (44). 124. Notocotylus verrucosus Froeh., after Olsson (72). 125. Ogmogaster plicata Crep., after Jägerskiöld from Bronn (3). 126. Stictodora sawakinensis Lss., after Looss (44). 127. Galactosomum lacteum Jäg., after Jägerskiöld (14). 128. Haplorchis cahirinus Lss., after Looss (44). 129. Mesometra orbicularis R., after Lühe (54). 130. Cotylotretus rugosus Odh., after Odhner (71).

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NOTES AND LITERATURE.

BOTANY.

Recent Literature on Germination. — The germination of the seed of *Carapa guianensis* Aubl. is described by Harshberger in *Proceedings of the Academy of Natural Sciences of Philadelphia*, Vol. LIV (1902), pp. 122–125, Pl. VIII. The seeds are without endosperm, the reserve material of the cotyledons being oil, proteid bodies, and protoplasm. The seeds would seem to lose their vitality more or less quickly; the period of germination is gone through quite rapidly, the plants reaching a height of about a foot and having produced several well-developed pinnate leaves in a month's time. They start to germinate before falling out of the capsule; all may germinate *in situ* and soon be so closely bound together by the intricately woven mass of secondary roots that it is hard to separate them. The germination of *Carapa guianensis* and *Xylocarpus granatum* (= *Corapa maluccensis*) is somewhat similar, the greatest difference being the formation of a tuber-like radicle and pneumatodes in *C. maluccensis*, a tree of mangrove habit.

Elenora Armitage finds (*New Phytologist*, Vol. I (June, 1902), pp. 127–128), that seeds of *Euphorbia peplus* germinate after being kept in a dry place for nearly nine years. She further shows that the seeds of this species, an annual, will germinate as soon as sown. The results are of interest in comparison with those of Winkler (*Berichte der deutschen botanischen Gesellschaft*, Vol. I), who found that seeds of *Euphorbia cyparissias*, a perennial, germinated first from four to seven years after they ripened, and those of *E. exigua*, an annual, nine years after ripening. She suggests that the so-called resting period is usually a delay due to the presence of a hard testa which requires moistening. It may be mentioned here that the seeds of *Nelumbium luteum*, for example, germinate at once when an opening is filed in the hard shell, but only after long delay when this is left intact.

In the *Journal of the Linnean Society*, Vol. XXXV (July, 1902), pp. 396–402, Prof. John Percival considers the origin of calcium oxalate crystals in seedlings of *Trifolium hybridum* Linn., giving the

results of a considerable series of experiments. In the same number of this journal Francis Darwin makes use of germinating Setaria, Sorghum, and *Vicia faba* in experiments on gravitational sensitiveness of the root tip.

A very interesting paper by Ethel Sargent, "The Origin of the Seed-Leaf in Monocotyledons" (*New Phytologist*, Vol. I, pp. 107–113, Pl. II), gives some of the results of five years' work on the vascular system in monocotyledons. She points out the fact that theoretically taxonomic characters drawn from the embryo are entitled to special attention in plants as in animals, but that so far the only important strictly embryonic character of acknowledged value is that employed in the fundamental division of the apparently well-defined group of angiosperms. Concluding that a detailed study of the seedlings of one family would yield results of greater value than a general study, work for the last four years has been confined to the Liliaceæ, of which seedlings of sixty genera have been collected and preserved, but the detailed examination of which is not yet completed. She considers that there is now no doubt of the systematic value of the indications given by the vascular structure of the cotyledon, hypocotyl, and primary root. At the same time, these indications she considers not easy of interpretation, since they are often wholly or in part concealed by adaptive characteristics which are the effect of environment upon an organism at a time when it is so little differentiated as to be extraordinarily plastic. In the hypocotyl she found the effects of this influence the least marked, but even here the structure must be affected by alternations in that of the cotyledon and root. In Anemarrhena she found a type of vascular arrangement from which others have clearly been derived, and that this form is truly symmetrical throughout. This type seems to be the starting point of at least four central tribes in the Liliaceæ, and must therefore be a form of some antiquity among monocotyledons. A comparison of some Ranunculaceæ, especially Eranthis, Nigella, and *Ranunculus ficaria*, of well-known monocotyledonous affinities, strengthened her opinion that the Anemarrhena type is a dicotyledonous one, and to conceive of steps by which two separate cotyledons may gradually unite, is, she thinks, easier than to conceive of a single cotyledon splitting into two similar members, as suggested by Lyon for Nelumbium. In conclusion, she says that there is no evidence of weight for the superior antiquity of monocotyledons, and that in this group the complete union of two cotyledons may possibly be due to their common specialization as an absorbing organ.

J. A. HARRIS.

Leaves of aquatics. — McCallum[1] gives the results of experiments designed to discover the factors determining the production of the well-known air and water forms of leaves in *Proserpinaca palustris*. After describing the form and anatomy of the two types of leaves, he gives the results of his experiments, which seem to show that the production of the submerged, much-dissected type, or the aërial, simply serrate type, is not determined by difference in illumination, nutrition, depth of water, temperature, stimulating influence of salts, variation of concentration of CO_2 or O, or contact stimulus. When, however, the plants were grown in a saturated atmosphere, a type of leaf very close to the regular submerged type is produced, and when plants grown under water are subjected to artificial transpiration induced by a change in osmotic pressure secured by a solution of mineral salts in the water, the air type of leaf was produced. Further experiments, the results of which will be presented later, are in progress.

J. A. HARRIS.

Notes. — The *American Journal of Pharmacy* for September contains an article on *Hyoseyamus muticus*, by Nagelvoort, and an account of the drug and medicinal-plant investigations in the Department of Agriculture, by True.

In the *American Journal of Science* for September, Fernald discusses the relationship of some American and Old-World birches; Sellards describes the fertile fronds of Crossotheca and Myriotheca, and the spores of other Carboniferous ferns, and also the validity of *Idiophyllum rotundifolium*, a fossil plant from the Coal Measures.

The *Bulletin of the Torrey Botanical Club* for August contains the following articles: Slosson, "The Origin of *Asplenium ebenoides*" (including the results of artificial hybridization of *Camptosorus rhizophyllus* and *Asplenium platyneuron*, and confirming the assumed hybrid nature of *A. ebenoides*, except that the artificial hybrids have not yet been made to fruit); Evans, "Hepaticæ of Puerto Rico"; White, "The Saltatory Origin of Species"; and Eastwood, "New Western Plants."

In Engler's *Botanische Jahrbücher* of August 29 are published the conclusion of Miss Perkins's "Beiträge zur Kenntnis der Stryracaceæ"; a monographic synopsis of the genus Lisianthus, by the same

[1] McCallum, W. B. On the Nature of the Stimulus causing the Change of Form and Structure in Proserpinaca palustris, *Botanical Gazette*, vol. xxxiv (August, 1902), pp. 93–108, Figs. 1–10.

author; a paper on *Nectria moschata*, by Glück; one on the anatomy of Anonaceæ, by Beyer; a study of Berberidaceæ, by Tischler; a supplement to Miss Perkins's monograph of Monimiaceæ; a paper by Hennings, on the fungi of Japan; a discussion of the wind as a factor in plant geography, by Warming; and a paper on the geographical distribution of mosses in middle Europe.

The Beiblatt, No. 70, of the same number, contains Dr. Clements's paper on a system of nomenclature for phytogeography, read in Denver last year, with concise comments by Professor Engler, and No. 4 of Urban's "Plantæ novæ americanæ, imprimis Glazovianæ," dealing with palms, and written by Dammer.

The *Ottawa Naturalist* for September contains a paper on the arboretum and botanic garden at Ottawa, and a short account of the plants at Norway Bay, Bristol, both by W. T. Macoun.

Professor Greene, who had thought of discontinuing *Pittonia* at the conclusion of the fourth volume, has decided differently, and under dates of September 9 and September 18 issues the first fifty-six pages of the fifth volume. These two installments include the following papers: "New or Critical Species of Acer," "A New Study of Microseris," "Some Phacelia Segregates," "Segregates of *Viola canadensis*," "Some New Acaulescent Violets," "Revision of Romanzoffia," "Revision of Capnorea," "New Species of Cryptanthe," and "A Fascicle of New Compositæ."

Torreya for September contains the following articles: Kirkwood, "The Vegetation of Northwestern Oregon"; Peirce, "Extrusion of the Gametes in Fucus"; Lloyd, "Mutual Irregularities in Opposite Leaves"; Earle, "A Key to the North American Species of Lactarius"; Kraemer, "The Pith Cells of *Phytolacca decandra*"; and Rydberg, "A New Station for *Isotria affinis*."

K. K. Mackenzie and B. F. Bush have issued a manual of the flora of Jackson County, Missouri, which includes descriptions of 1141 species and 50 additional varieties, contained in 500 genera. This differs from the usual local floras in being a descriptive handbook, with keys to the higher groups and to the species of the larger genera.

In the *Sierra Club Bulletin* for January Miss Eastwood gives an account of Trinity County, California, with a list of the trees and shrubs found in that county.

The shrubs of Wyoming form the subject of *Bulletin 54* of the Wyoming Experiment Station, written by Elias E. Nelson.

The *Bulletin of the Geographical Society of Philadelphia* for April contains a report of the Brown-Harvard expedition to Labrador in 1900, and includes an extensive account of the botany of the expedition, with lists of the plants collected.

The *West American Scientist* for August, selling for ten cents, and Mr. Orcutt's *Review of the Cactaceæ* for the same month, selling for twenty-five cents, consists of the same signature of cactus notes.

A photogram of *Echinocactus cylindraceus* is contained in the August number of the *Monatsschrift für Kakteenkunde.*

Die Gartenwelt of August 23 contains an article on noteworthy trees of Hanover, illustrated by a number of pictures of trees growing under unusual conditions and displacing objects in their way.

Fasciation in the leaves of *Euonymus japonicus* is described by De Camps in the *Memorias de la Real Academia de Ciencias y Artes de Barcelona*, Vol. IV, No. 20.

The exhibition of botanical objects under the microscope in museums is the subject of an illustrated article by Howe in the *Journal of the New York Botanical Garden* for September.

The *Yearbook of the Department of Agriculture* for 1901, in addition to the usual administrative and statistical portions, contains a large number of economic articles, many of them of botanical interest.

The many publications of the U. S. Department of Agriculture, including those issued by the Patent Office, have been listed by the division of publications of the department in a recently issued bulletin, which will prove very serviceable to libraries possessing sets of these publications. A catalogue of the botanical publications in the library of the same department, by Miss Clarke, constitutes *Library Bulletin No. 22* of the department.

An interesting item in *Advance Sheets of Consular Reports* of August 30 shows that during July one hundred and eighty thousand bunches of bananas were shipped from Puerto Cortes, Honduras, to New Orleans and Mobile, and one hundred thousand additional bunches were paid for and destroyed by the contractors.

An economic study of berseem (*Trifolium alexandrinum*), much cultivated in the Nile valley, forms the subject of *Bulletin No. 23* of the Bureau of Plant Industry of the U.S. Department of Agriculture, written by Fairchild.

Nos. 50 and 51 of the *Contributions from the Cryptogamic Laboratory of Harvard*, published respectively as Nos. 2 and 3 of Vol. XXXVIII of the *Proceedings of the American Academy of Arts and Sciences*, are: "Preliminary Diagnoses of New Species of Laboulbeniaceæ," V, by Thaxter; and a paper on *Cauloglossum transversarium*, by Johnston.

A monograph of the Acrasieæ, by E. W. Olive, forms No. 6 of the current volume of the *Proceedings of the Boston Society of Natural History*. This is another of the foundation-laying studies from the cryptogamic laboratory of Harvard.

A biographical sketch of Marc Micheli, with an excellent portrait, has been distributed by M. de Candolle, from the *Archives des Sciences Physiques et Naturelles* for July.

CORRESPONDENCE.

Editor American Naturalist:

In the July number of the *American Naturalist*, among his "Notes on the Cœlenterate Fauna of Woods Hole," Dr. C. W. Hargitt has defined what he considers to be a new species of tubularian hydroid, under the name of *Tubularia parasitica*. During the past summer I have been enabled to observe the development of the western representative of the genus *Corymorpha*, *C. palma*, a few facts concerning which will show, I think, that *T. parasitica* is but a young form of the *pendula* on which it was growing. It has seemed best that attention should be called to this at once to prevent future inconvenience to taxonomists.

As with *C. pendula*, the medusæ of *C. palma* are permanently attached. The eggs arise on the manubrium, break through the ectoderm when ripe, and, in quiet water, settle at once to the bottom. The egg case is adhesive, fastening to the first object with which it comes in contact. Many eggs are dropped at the same time, and often cling to the rootlets of the parent hydroid, where *T. parasitica* was found. There is no free larval stage. The embryo is able, however, to change its location very slowly, leaving a trail of perisarc behind it. Such a movement accounts for the clusters of six or eight individuals which are commonly found adhering to each other near their bases. The stem has a single central canal at first, as in Tubularia. The peduncles which support the medusæ appear very early. When there are not more than eight proximal tentacles, buds arise on the base of the hydroid and develop into rootlets. They are the structures, I suspect, which Dr. Hargitt has taken for "absorbent organs."

The young Corymorpha further agrees with *T. parasitica* in size, number of tentacles, and general aspect.

I shall describe the development of *C. palma* more fully in another connection.

HARRY BEAL TORREY.

ZOÖLOGICAL LABORATORY, UNIVERSITY OF CALIFORNIA,
BERKELEY, CAL., Sept. 5, 1902.

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